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Engineering Evaluation/ Cost
Analysis Report
Greiner's Lagoon Site
Fremont, Ohio

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On July 30, 1991, The Lubrizol Corporation (Lubrizol) entered into an Administrative Order by Consent (AOC) with U.S. EPA Region V pursuant to Section 106 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) to undertake actions to produce an Engineering Evaluation/Cost Analysis (EE/CA) for the Greiner's Lagoon Site in Sandusky County, Ohio. The EE/CA identifies and evaluates alternatives for a non-time critical removal action at the Site. Elements of the EE/CA included:

- Site characterization
- Streamlined risk evaluation and preliminary ecological risk assessment
- Identification of removal action objectives
- Identification and evaluation of removal action alternatives
- Recommendation of a non-time critical removal action for the Site

BACKGROUND

The Greiner's Lagoon Site is located south of Fremont, Ohio on County Road 181 about 1/2 mile west of Tiffin Road in Ballville Township, Sandusky County. The Site was originally developed by Mr. Terry Little in 1954 and consisted of four lagoons to store waste oil from nearby industry. After several changes in ownership, the Site was purchased by Mr. Gary Greiner in 1973. During the course of Site operations by the various owners, a number of community complaints and legal actions were undertaken because of odors and releases from the lagoons. In 1980, a judgment handed down by the Sandusky Court of Common Pleas ordered Mr. Greiner to clean up the Site. He did not comply with the order.

In 1981, 1982 and 1986-1988, U.S. EPA implemented Site removal actions including lagoon dike reinforcement, surface oil removal, liquids treatment and discharge, sludge solidification, lagoon backfilling, and placement of a soil cover over the filled lagoons. Between 1982 and 1985, Ohio EPA coordinated the delivery of sand and gravel washings from the processing of sugar beets and placement of the material in the open lagoons.

In July 1991, Lubrizol entered into the AOC with U.S. EPA Region V, under which this EE/CA was developed. During August 1991, Lubrizol arranged for the removal of the access road adjacent to the Site, improvement of surface water drainage, and installation of a fence to improve Site security. In 1997 and 1998, Lubrizol repaired areas of visible seepage at the Site using compacted clay, topsoil and seeding, and riprap.

1.2

SITE CHARACTERIZATION

Site investigations conducted under the EE/CA indicated that approximately 35 feet of soil overlies the limestone bedrock at the Site. Generally, the upper 8 to 10 feet of naturally occurring soil is either silty sand, sand, or silty clay. The soil deeper than 8 to 10 feet is primarily clay or silty clay. The Site data indicate that this clay/silty clay, which is approximately 25 feet thick, acts as a confining layer for the regional bedrock aquifer. Monitoring of the bedrock aquifer at the Site showed that the localized bedrock ground water flow direction is generally to the east-northeast. Monitoring also indicated that there is a shallow saturated zone, under perched water conditions on top of the clay/silty clay, at a depth of approximately 4 feet below the ground surface. This shallow zone generally radiates away from the drainage ditch on the northeast end of the Site. The shallow monitoring wells indicate that the localized flow direction of the shallow saturated zone is generally toward the north west, west and southwest with an average hydraulic gradient of 0.008 ft/ft, an average hydraulic conductivity of 2.51 ft/day and an average ground water velocity of 0.084 ft/day.

The shallow ground water is not used as a water supply source in the area. This shallow ground water will not be used for potable purposes due to its low yield, the location of the higher yielding bedrock aquifer at a depth of approximately 35 feet, and restrictions imposed by the Ohio Department of Health requiring that water well depths must be > 25 feet below ground surface. In addition, all of the remedial action alternatives evaluated in the EE/CA include institutional controls, such as, improved fencing and security to control access to the Site and/or deed restrictions.

As indicated on the ODNR well logs and ERM-prepared soil boring/well logs, the subsurface geology consists of a clay/silty clay unit (> 25 feet thick) between the shallow saturated zone and the bedrock aquifer. Based on the presence of this clay unit, geotechnical testing of the clay unit, differences in water level data and the differences in hydraulic gradient between the two units, the shallow saturated zone and bedrock aquifer are not connected.

Samples were collected of the stabilized material in the areas of the former lagoons for physical and chemical characterization. From the chemical analyses of the stabilized material, a list of indicator compounds was compiled to guide the laboratory analyses of subsequent soil and ground water samples. Sampling and analysis of the soil indicated that the primary impacts are from acetone, 4-methyl-2-pentanone, phenol, and bis(2-ethylhexyl) phthalate at depths less than 10 feet in the Consolidation Area. Sampling of the bedrock ground water identified acetone and lead at very low levels that do not pose unacceptable risk for consumption. The principal constituents detected in the shallow (perched) ground water were acetone, benzene, 4-methyl-2-pentanone, phenol, arsenic, chromium, and lead. As mentioned above, the shallow ground water is not used as a water supply source in the vicinity of the Site. Ground water samples collected from monitoring wells installed in the field surrounding the lagoons indicated that low levels of acetone and 4-methyl-2 pentanone are present.

Sampling and analysis of the surface water and sediment in the drainage ditch east of the Site showed no significant impacts to these environmental media.

1.3

STREAMLINED RISK EVALUATION

A streamlined risk evaluation (SRE) of the Site was conducted and identified three human receptor groups as having potential current or future exposures at the Site. These human receptor groups consist of future construction workers, local residents who may contact affected off-site soil and who may use the bedrock ground water as a drinking water source and occasional trespassers.

The estimated carcinogenic and noncarcinogenic risks for the on-Site construction worker who may be exposed to off-site soils and off-site perched ground water were below the acceptable benchmarks established by U.S. EPA. However, potential construction worker exposures to on-site soils and on-site perched ground water resulted in risk marginally above the benchmarks. The carcinogenic risk for exposure to on-site soil was estimated at 4×10^{-6} , which is only slightly above USEPA's cancer risk benchmark of 1×10^{-6} . The noncarcinogenic risk was estimated at 5. The carcinogenic risk for exposures to on-site perched ground water was estimated at USEPA's benchmark of 1×10^{-6} . The noncarcinogenic risk was estimated at 1.8 which is slightly above the acceptable hazard index of 1.0. These potential risks can be readily mitigated by employing routine health and safety measures for any on-Site construction. There

were no significant estimated risks for the construction worker from potential exposure to the surface water and sediment in the drainage ditch.

The SRE found that the estimated risks for local residents who may have contact with off-site soil and who could use bedrock ground water as a drinking water supply were below the benchmarks established by U.S. EPA.

The estimated carcinogenic risk calculated for the occasional trespasser potentially exposed to on-site soil was marginally above the benchmark of 1×10^{-6} , but well within the acceptable range of 1×10^{-4} to 1×10^{-6} . The noncarcinogenic risks estimated for the trespasser were also well below the acceptable hazard index of 1.0. There were no significant estimated risks to the hypothetical trespasser from potential exposure to the surface water and sediment in the drainage ditch east of the Site.

1.4

SCREENING AND PRELIMINARY ECOLOGICAL RISK ASSESSMENT

A screening and preliminary ecological risk assessment, including an ecological reconnaissance, was performed for the Site. The ecological risk assessment found that the habitats and associated wildlife at the Site are typical of the predominantly agricultural land use of northwest Ohio. Potential ecological receptors could be at risk due to erosion and storm water runoff during times of high or prolonged rainfall. It is important to note, however, that as part of a removal action in 1987, the USEPA installed a clean soil cover over the Consolidation Area. Thus, no affected material should be available for exposure, except for limited areas where this cover may have been breached. In addition, exposure of ecological receptors in these areas will be limited due to the limited size of the impacted area and the lack of wildlife attractant value (food or cover resources).

Neither the drainage ditch east of the Site nor Indian Creek, into which the ditch discharges, contain suitable habitat for aquatic communities because of modifications to enhance drainage for agricultural purposes. The waterways have no vegetative cover and have been channelized and deepened with steep banks. The adjacent fields have been farmed up to the edges of the waterways. In addition, samples of the surface water and sediment from the nearby drainage channel indicate little impact from the Site.

Contacts with government agencies and the Site reconnaissance did not identify any federal threatened or endangered species at the Site that could be impacted by potential removal actions. No plant and animal species of special interest in Sandusky County have been observed in the vicinity of the Site.

A formal wetland delineation was not conducted as part of the Site reconnaissance. However, the total potential wetland area on the west side of the Site receiving surface water runoff from the Consolidation Area is estimated to be less than one acre. The drainage ditch on the east side of the Consolidation Area which also receives surface water runoff is not likely to be classified as a jurisdictional wetland by the Army Corps of Engineers. Thus, these areas would not be subject to regulation under the Army Corps of Engineers or the Ohio EPA Division of Surface Water Quality (Personal Communication, Ohio EPA Division of Surface Water Quality, 1999).

1.5

REMOVAL ACTION ALTERNATIVES

Based on the results of the site investigations and risk assessments, the objective and scope for the non-time-critical removal action at the Greiner's Lagoon Site is to mitigate the risks to human health and the environment. The human health risk assessment identified the following risks slightly above U.S. EPA thresholds for the Site:

- **Carcinogenic Risks - Exposure of On-Site Soil to the Future Construction Worker and Adolescent Trespasser**
- **Non-Carcinogenic Risks - Exposure of On-Site Soil to the Future Construction Worker and Exposure of On-Site Shallow Ground Water to the Future Construction Worker**

In summary, there are no unacceptable off-site risks at the site.

Following the identification of the removal action objective, candidate removal action technologies were screened based on effectiveness, implementability, and cost. The various technologies that passed the screening were combined into several removal action alternatives that met the Site removal action objective. These alternatives included:

- **Alternative 1: Engineered Clay Cap; Selective Soil Physical Solidification; Access Control and Monitored Natural Attenuation**

- Alternative 2: Engineered Clay Cap; Soil Chemical Stabilization; Access Control and Monitored Natural Attenuation
- Alternative 3: Excavation; Off-site Landfilling; Access Control
- Alternative 4: OAC 3745-27-11 Cap, Selective Soil Physical Solidification; Access Control and Monitored Natural Attenuation
- Alternative 5: OAC 3745-27-11 Cap, Soil Chemical Stabilization; Access Control and Monitored Natural Attenuation
- Alternative 6: Phytoremediation (Hydraulic Control and Treatment); Access Control and Monitored Natural Attenuation

An evaluation was made of the projected environmental effects and performance of the removal action alternatives. The evaluation criteria included:

- Timeliness
- Protection of Human Health and the Environment
- Technical Feasibility
- Major Institutional Considerations
- Cost Analysis

The evaluation of the removal action alternatives determined that all six alternatives are technically feasible, would be effective in protecting human health and the environment, and can be constructed within one calendar year. The estimated present worth cost of the various Alternatives ranges from \$1.2 to \$8.8 million. The estimated present worth costs are:

- Alternative 1: Engineered Clay Cap; Selective Soil Physical Solidification; Access Control; Monitored Natural Attenuation; \$2.0 million.
- Alternative 2: Engineered Clay Cap; Soil Chemical Stabilization; Access Control; Monitored Natural Attenuation; \$6.0 million.

- **Alternative 3:** Excavation; Off-site Landfilling; Access Control; \$8.8 million.
- **Alternative 4:** OAC 3745-27-11 Cap, Selective Soil Physical Solidification; Access Control; Monitored Natural Attenuation; \$2.4 million.
- **Alternative 5:** OAC 3745-27-11 Cap, Soil Chemical Stabilization; Access Control; Monitored Natural Attenuation; \$6.5 million.
- **Alternative 6:** Phytoremediation (Hydraulic Control and Treatment); Access Control; Monitored Natural Attenuation; \$1.2 million.

Based on the evaluation and comparison of the removal action alternatives, either Alternative 6: Phytoremediation (Hydraulic Control and Treatment); Access Control, and Monitored Natural Attenuation or Alternative 4: OAC 3745-27-11 Cap, Selective Soil Physical Solidification; Access Control and Monitored Natural Attenuation is the recommended removal action. The remedies: (1) will achieve the removal action objective for the Site (i.e., eliminates the small potential risk to future construction workers from exposure to consolidated materials and impacted soil, and hypothetical ecological receptors from storm water run-off), (2) can be readily implemented and maintained, (3) controls infiltration of water into consolidated materials, thus minimizing the possibility of constituents leaching out of materials and migrating to ground water, (4) reduces the mobility/toxicity/concentrations of constituents in the media of concern, and (5) have costs on the lower end of the cost range.

2.0

BACKGROUND AND PREVIOUS REMOVAL ACTIONS

2.1

BACKGROUND

The Site is located south of Fremont, Ohio, on County Road 181 about 1/2 mile west of Tiffin Road in Ballville Township, Sandusky County, Ohio (Figure 1-1). The Site was originally developed by Mr. Terry Little in 1954, and consisted of four lagoons to store waste oil collected from nearby industry (Figure 1-2). A letter from the community, sent to Mr. Little in 1960, complained of odors emanating from the lagoon and of animals being killed or trapped by the oil. In response to the complaints from the community, Ohio Department of Health ordered Mr. Little to cease dumping oil into the four lagoons in 1970.

In 1972, Mr. Little traded the property to Beatrice and Edgil Collins in return for well drilling services. The Collins then sold the property to Mr. Nobel Caseman in 1973. During Mr. Caseman's period of ownership, a lawsuit was filed by members of the community against the original owner, Mr. Terry Little. By order of the Sandusky County Court of Common Pleas, Mr. Little was required to take measures to prevent any release of oil from the Site. In response, Mr. Little constructed dike systems around the four lagoons.

In the latter part of 1973, Mr. Caseman sold the property to Gary Greiner, the present owner. From 1973 until the latter part of 1974, Mr. Greiner used the Site for disposal of demolition debris. In November of 1974, the Ohio EPA ordered Mr. Greiner to clean up the Site. Because Mr. Greiner failed to comply with the order, the case was referred to the Ohio Attorney General who filed a suit in the Sandusky Court of Common Pleas in 1975. A judgment was handed down in September, 1980, ordering Mr. Greiner to clean up the Site by January 15, 1981. Mr. Greiner did not comply with the order.

2.2

PREVIOUS REMOVAL ACTIONS

On June 16, 1981, heavy rains caused the lagoons to overflow. Oil contaminated with polychlorinated biphenyls (PCBs) was released onto the adjoining farm land and into a nearby drainage ditch. Some of the contaminated oil flowed into Indian Creek via the drainage ditch and eventually to the Sandusky River. On June 17, 1981, the U.S. EPA

reinforced the dikes around the lagoons. A dike was also built to contain a previous spill in a low area around the lagoons.

In June of 1981, surface oil was collected from the lagoons and stored on-site in two tanks totaling 12,000 gallons. Liquid from Lagoons 3 and 4 was siphoned off and passed through a carbon contact unit that was constructed on-site in a 20,000 gallon tank. Effluent from the carbon unit was discharged to the nearby drainage ditch. Lagoon 4 was dewatered, filled and capped. Closure and grading of this lagoon was completed in June 1982, as a CERCLA-funded immediate removal action. Another action undertaken as part of this cleanup was the partial dewatering of Lagoon 3.

Between the summers of 1982 and 1985, Ohio EPA coordinated the delivery of several truckloads of "sugar beet fines," sand and gravel washings from the cleaning and processing of sugar beets, and dumping of the fines in the remaining open lagoons. Lagoons 1 and 2 were filled in.

In May, 1986, Lagoon 3 again overtopped the western dike. U.S. EPA then undertook an immediate removal action to build up the freeboard of the lagoon and prevent the off-site migration of contaminants. Sandbags were used to construct a temporary retention dam and to raise the level of the western dike.

In the fall of 1987, the U.S. EPA undertook a removal action that consisted of the following:

- On-site treatment and discharge of impounded water
- Stabilization of oils and sludges in Lagoon 3
- Consolidation of Lagoon 3 stabilized material on former Lagoons 1 and 2
- Covering of all stabilized material with soil
- Site regrading

These removal action activities were completed in June, 1988. The actions completed to date have resulted in the temporary stabilization of the Site.

U.S. EPA's activities at the Site are summarized in its On-Scene Coordinator's Report, CERCLA Removal Project, Greiner's Lagoon (undated). The available information about U.S. EPA's removal actions indicates that Lagoon 3 had an area of approximately 4,300 square yards and a depth of about 4 feet. It is estimated that about 5,000 cubic yards of water, oil, and sludge were removed from Lagoon 3 during U.S. EPA's actions. The Agency's activities at the Site indicated the presence of

arsenic, barium, chromium, cobalt, lead, nickel, phenol, PCBs, and toluene in Site materials.

On July 30, 1991, The Lubrizol Corporation (Lubrizol) entered into an Administrative Order by Consent (AOC) with the U.S. EPA, Region V, pursuant to Section 106 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) to undertake actions to produce an Engineering Evaluation/Cost Analysis (EE/CA).

During August 1991, Lubrizol arranged for the removal of the access road adjacent to the Site. As part of the road removal, a drainage ditch was relocated onto the Site, and a portion of the adjacent property was regraded to promote drainage. In addition, in late August 1991, Lubrizol arranged for the installation of a fence on the Site for security.

In June 1997 two areas of visible seepage were repaired at the site. A 20-foot by 20-foot area located along the sideslope of the northern lagoon and an area south of the mound were repaired. For the northern seep area, visibly impacted soils were pulled back into the sideslope. For both areas, clay was placed over the area and compacted, resulting in a two-foot layer of compacted clay. Topsoil was placed over the clay in a thickness of approximately one foot. The topsoil was seeded. For the northern seep area, an erosion mat was placed over the topsoil. Approximately 20 cubic yards of riprap were placed at the toe of the impacted area to hold the clay/topsoil in place.

In 1998, additional areas of small seeps were repaired at the site. A temporary cover was installed to repair the impacted area which measured approximately 60 feet by 60 feet. This area was repaired by grading the area smooth with a low ground-pressure dozer, installing a layer of geotextile (Reinforcer 400R™). The geotextile was anchored in a shallow trench around the impacted area. An 8-inch layer of clay was compacted in place using the dozer blade and tracks. After the clay was placed, a 6-inch layer of top soil was applied with the dozer and the area was seeded. The seeded area was covered with straw erosion mat to prevent erosion of the topsoil. Following repair of this area, several small seeps developed near the northeast corner and southwest corner of the temporary cover. These seeps were in two areas, each measuring 3 feet by 3 feet. These seeps were repaired using the same procedures.

During the temporary remedial activities, a crushed 500-gallon steel tank was unearthed. A viscous oily material covered the interior of the tank sidewalls. A small amount of the oil material dripped out of a hole in the tank and onto the ground surface in the immediate vicinity of the tank. The tank contents were placed onto one of the seep areas and the tank was

cleaned. The tank was cut open with a torch and the cleaned tank was transported to a metal recycler.

PHYSIOGRAPHIC LOCATION

Sandusky County is situated in the broad lake plain section of the Central Lowlands Province. The site is located in the south central portion of the County between the Sandusky River to the south and west and the Indian Creek tributary to the north and east. The surface water drainage patterns are channeled through county drains which flow generally northward toward Indian Creek which discharges into the Sandusky River, which flows into Lake Erie. The local topography is nearly flat with a general slope from the southeast corner of Sandusky County to the Sandusky Bay.

GEOLOGY

Based on drilling observations and a review of local geologic maps and United States Geological Survey (USGS) data, the shallow Site stratigraphy consists primarily of glacial and alluvial deposits made of interbedded sands, silts, and clays. These unconsolidated deposits were deposited by glacial activity during the Pleistocene Epoch of the Quaternary Period. These deposits locally vary in thickness from 20 to 50 feet below ground surface.

As indicated in the drilling logs (Appendix A), the site specific unconsolidated deposits were approximately 35 feet thick above the bedrock. Figures 3-1 to 3-4 present cross-sections of the unconsolidated site stratigraphy. The cross-section locations are presented on Plate 1. Generally, the upper 8 through 10 feet of the naturally occurring deposits (outside the lagoon area) consist of either silty sand, sand, or silty clay. Depths greater than 8 to 10 feet below ground surface consist primarily of silty clay or clay. This clay/silty clay, which is approximately 25 feet thick, acts as a confining unit for the regional bedrock aquifer.

Bedrock encountered at the Site consists of the Lockport Dolomite which was deposited during the Silurian Period. The bedrock was encountered at a depth of approximately 35 feet below grade. The Lockport Dolomite composes the eastern flank of the Findlay Arch which is a prominent bedrock anticlinal structure in northwestern Ohio. The anticlinal structure exposes older units on the crest of the arch and successively younger bedrock units to the east and west.

The principal aquifer system in the northwest Ohio region is contained within the carbonate bedrock units that compose the Findlay Arch. At the subject Site, the primary aquifer lies within the Lockport Dolomite. As with most carbonate rocks, the ground water principally flows through secondary porosity such as fractures, along bedding planes, and through solution channels. Well yields are attributable to the degree of penetration into interconnected fractures or solution channels within the aquifer. The average yield of the Lockport Dolomite is 100 gallons per minute.

Ground water elevation data demonstrate that the ground water surface in the bedrock aquifer monitoring wells (MW-1, MW-2, and MW-3) is approximately 20 feet below ground surface. The depth to bedrock, however, is at a greater depth of approximately 35 feet below ground surface. The actual ground water surface in the primary regional aquifer is within this bedrock. The elevated ground water surface above the depth to bedrock in the monitoring wells suggests that the primary regional aquifer is under confined conditions. This could be attributed to the clay/silty clay overlying the bedrock at the site. The clay/silty clay overlying the bedrock isolates the ground water in the bedrock from the atmosphere, therefore the bedrock aquifer is generally subjected to pressures higher than atmospheric pressure. The water levels in the bedrock wells represent the confining pressure at the top of the bedrock aquifer. The elevation to which water rises in a well that is installed into a confined aquifer is called its potentiometric level.

Plates 2, 3, 4 and 4A present the ground water flow in the bedrock aquifer for July 1996, November 1998, January 1999 and April 1999, respectively. The bedrock monitoring wells (MW-1, MW-2, and MW-3) indicate that the localized flow direction of the regional aquifer is toward the east-northeast with a hydraulic gradient ranging from 0.0003 to 0.00007 ft/ft and an average hydraulic gradient of 0.0004 ft/ft.

Ground water elevation data was collected from the shallow monitoring wells (MW-4, MW-5, MW-6, MW-7, and MW-8) and the newly installed shallow monitoring wells (MW-9, MW-10, MW-11, MW-12, MW-13, and MW-14) for July 1996, November 1998, January 1999, and April 1999. The ground water elevation data is presented in Tables 3-1, 3-2, 3-3 and 3-4.

Plates 5, 6, 7 and 7A present the flow of water in the shallow saturated zone for July 1996, November 1998, January 1999 and April 1999, respectively. The shallow monitoring wells indicate that the localized flow direction of the shallow saturated zone is generally toward the northwest, west and southwest with a hydraulic gradient ranging from

0.0005 to 0.0125 ft/ft and an average hydraulic gradient of 0.008 ft/ft. Accordingly, these data demonstrate a general flow direction that radiates away from the drainage ditch on the northeastern end of the site. This suggests that the drainage ditch could be a recharge point from surface water runoff.

The November 1998 ground water elevation data indicates a mounding effect of the shallow saturated zone near monitoring well MW-6. During this time period, flow in that saturated zone may radiate in all directions from the area of MW-6. The flow in the shallow saturated zone is sensitive to seasonal water elevation fluctuations. However, it appears that the flow direction of the shallow saturated zone is generally toward the northwest, west and southwest.

The shallow saturated zone will not be used for potable purposes due to its low yield, the location of the higher yielding bedrock aquifer at a depth of approximately 30 feet, and restrictions imposed by the Ohio Department of Health requiring that water well depths must be > 25 feet below ground surface. In addition, the pumping of a residential bedrock well would have minimal influence on the water levels in the bedrock and virtually no measurable influence on water levels in the shallow saturated zone.

As indicated on the ODNR well logs (Appendix B) and the ERM-prepared soil boring/well logs, the subsurface geology consists of a clay/silty clay unit (> 20 feet thick) between the shallow saturated zone and the bedrock aquifer.

To confirm the presence of a confining unit separating the shallow saturated zone from the deeper bedrock aquifer at the Greiner's Lagoon Site, six soil borings (GT-1 to GT-6) were advanced in February 2000. The borings were placed in the following locations: one soil boring just north of the site, one soil boring just south of the site, two soil borings just east of the site, and two soil borings just west of the site (Plate 1).

The borings were advanced using hollow stem augers with a motorized drill rig to just above bedrock. Shelby tube samples were collected for the purpose of physical testing. An ERM geologist was on-site during soil boring advancement to characterize the subsurface geology.

Shelby tube sample collection points were collected from depths generally 16 to 21 feet in the silty clay and 28 to 30 feet in the clay in each soil boring. The shelly tube samples were extruded in the geotechnical laboratory and tested for permeability, grain size, unit weight, Atterburg limits, and classified using the USCS classification system.

Appendix C1 presents the results of the geotechnical testing of the clay units. Each of the samples were classified as Silty Clay or Clay. The permeability of the samples ranged from 1.4×10^{-7} cm/sec. to 8.4×10^{-8} cm/sec. for the 16 to 21 foot interval and ranged from 1.5×10^{-7} cm/sec. to 5.0×10^{-8} cm/sec. for the 28 to 30 foot intervals.

Based on the presence of this low permeability clay unit, and the differences in water level elevation data and the differences in hydraulic gradient between the two units, the shallow saturated zone and bedrock aquifer are not connected.

Hydraulic Conductivity Testing Results-Shallow Saturated Zone

Hydraulic conductivity tests were conducted at eight of the shallow monitoring wells (MW-05, MW-06, MW-7, MW-08, MW-09, MW-10, MW-11, and MW-13).

The Bouwer and Rice (1976) method was used to evaluate the data. The Bouwer and Rice Method was developed to measure the hydraulic conductivity around the screen of fully or partially penetrating wells in unconfined aquifers. The Bouwer and Rice method's governing equation is:

$$K = \frac{r_c^2 \ln\left(\frac{R_e}{r_c}\right)}{2 L_e} \cdot \frac{1}{t} \ln \frac{Y_o}{Y_t}$$

where:

- K = hydraulic conductivity,
- r_c = well casing radius (feet),
- R_e = effective radial distance over which the head is dissipated,
- r_w = radial distance between well center and undisturbed aquifer,
- L_e = length of saturated screen,
- Y_o = water level Y at time zero,
- Y_t = water level Y at time t, and
- t = time since Y_o .

The values calculated for hydraulic conductivity ranged from 0.07 to 5.80 (ft/day). The hydraulic conductivity results are presented in Table 3-5 and the graphs of the data are presented in Appendix C.

Many of the overburden wells have water levels within the length between the top of the screen and the top of the sand pack. The interpretation of the data from these wells required the use of two of the different Bouwer and Rice Cases; one with gravel pack drainage, and one without gravel pack drainage so that a range of values are presented for several wells.

Well Yield

Individual well yields were estimated for the wells tested using a method described by Driscoll (1986). This method estimates the well yield at one half of the available drawdown:

$$Q = \frac{T}{2000} * \frac{b}{2}$$

where:

- Q = well yield (in gpm)
- T = transmissivity (gal/day/ft), and
- b = available drawdown (ft)

The estimated well yields for the shallow wells range from 0.01 to 1.78 gpm and are presented in Table 3-5.

Ground Water Velocity

A site ground water velocity was calculated based on the hydraulic gradient at the site and the results of the hydraulic conductivity testing. The hydraulic gradient was determined from depth to water readings that were collected at the site on 10 November 1998 and 27 January 1999. The shallow overburden hydraulic gradient is approximately 0.01 ft/ft. The average hydraulic conductivity for the shallow saturated zone is approximately 2.51 ft/day. The ground water velocity is calculated using the following equation:

$$V = \frac{K}{n} * \frac{dh}{dl}$$

where:

- V = ground water velocity,
- K = hydraulic conductivity,
- n = porosity, and
- dh/dl = hydraulic gradient

Assuming a porosity of 0.3, the average ground water velocity in the shallow saturated zone is 0.084 ft/day (30.7 ft/year).

VOC Migration Velocity

An estimate of the site VOC migration velocity has been calculated for the site following a method presented in Freeze and Cherry (1979). This method calculates the site VOC migration velocity from the site ground water velocity, a VOC partitioning coefficient (K_{oc}), and a total organic content (f_{oc}) analysis of site soils. The VOC migration velocity is calculated by using the following equation:

$$V_c = \frac{V}{(1 + (\rho_b / n)(K_d))}$$

where:

- V_c = velocity of the organic compound in ground water,
- V = velocity of the ground water,
- ρ_b = bulk density of the aquifer,
- n = effective porosity, and
- K_d = distribution coefficient

The distribution coefficient is a parameter describing the affinity of nonpolar organic compounds to the aquifer matrix and is calculated by multiplying the total organic carbon content (f_{oc}) and the compound's respective partitioning coefficient (K_{oc}), thus $K_d = (K_{oc})(f_{oc})$. The partitioning coefficient (K_{oc}) for Acetone 2.2 ml/gm was used for this calculation. Three soil samples from the site (from MW-11, MW-12, and MW-13) were analyzed for total organic content (f_{oc}). The f_{oc} values were determined to be 0.0070, 0.0054 and 0.0068 respectively.

Using a bulk density for the aquifer of 2.65 gm/cm³, and an effective porosity of 30 percent, the average VOC migration velocity for the shallow saturated zone is estimated to be 0.077 ft/day or 28.1 ft/yr. Information on the VOC migration rate calculation is presented in Table 3-6.

This calculation is an estimate of the VOC migration velocity and it does not necessarily represent the shallow saturated zone as a whole due to heterogeneities, nor does the calculation consider factors affecting the VOC concentrations such as loading history, and natural attenuation processes such as dilution, dispersion, volatilization, and reduction/oxidation degradation.

4.0

SITE CHARACTERIZATION

This section of the report details the specific field tasks completed for the EE/CA. The Site characterization phase of the EE/CA consisted of an evaluation of the existing Site conditions.

The quantitation limits for the chemicals analyzed for during this EE/CA investigation are presented in Table 4-1.

4.1

SITE TOPOGRAPHIC SURVEY

A complete property and topographical survey of the Site was performed. This survey included the identification and location of all surface features, location of all property lines with bearings, distances and coordinates, the establishment of a grid system, and development of topographic contours on a one-foot interval. The survey was performed by Linn Engineering of Zanesville, Ohio, a registered surveying company.

4.1A

LAND USE, POPULATIONS, METEOROLOGY

Land use in the area of the Site and in most of Sandusky County is predominantly agricultural. Agriculture accounts for 85% of the land usage in Sandusky County. Corn, soybeans, wheat, oats, and hay are the predominant crops. Land use in the remainder of the county is primarily a mixture of commercial (including quarrying) and residential.

Sandusky County is cold and snowy in the winter and warm in the summer. The climate is temperate. In winter the average temperature is 27 degrees Fahrenheit. In summer the average temperature is 71 degrees Fahrenheit. The 30-year mean-annual temperature averages 50 degrees Fahrenheit. The total annual precipitation is approximately 33 inches. Of this, approximately 20 inches, or nearly 60 percent, usually falls in April through September. The average seasonal snowfall is 17.4 inches. The average relative humidity in midafternoon is about 60 percent. The prevailing wind direction is from the southwest. Average windspeed is highest, 11 miles per hour, in winter.

4.2.1

Phase I - Stabilized Material Sampling Procedures

In April 1996, soil borings were advanced at the ten locations shown in Plate 1. Locations SM-1 through SM-6 are in the Consolidation Area. Locations SM-7 and SM-8 are in the former Lagoon 3 area. Locations SM-9 and SM-10 are in the former Lagoon 4 area.

The borings were advanced using hollow stem augers with a motorized drill rig. Shelby tube samples were collected for the purpose of physical characterization, and split-spoon samples were collected for the purpose of chemical characterization. The depth of the soil borings ranged from 12 feet to 30 feet based on the thickness of the stabilized material in each of the areas.

Split-spoon samples were collected continuously (except for the Shelby tube intervals). Samples obtained from approximately one-third and two-thirds the estimated thickness of the stabilized material were shipped to the laboratory for chemical analysis. Additionally, split-spoon samples were collected from the base of the former lagoons and from the native material just below the base of the lagoons in the Consolidation Area, and from just below the fill material in former Lagoons 3 and 4.

Shelby tube samples were generally collected two feet below ground surface and at mid-depth at each boring location. A Shelby tube sample was collected from the capping material (0-2 foot depth interval) in each of the two borings in former Lagoon 4.

The shelly tubes were brought to the surface, both ends were sealed with end caps and wax, and the tubes were properly labeled. The two shelly tube samples of the capping material from former Lagoon 4 were to be extruded in a geotechnical laboratory and tested for permeability, grain size, Atterburg limits, and classified using the USCS classification system. All of the other Shelby tube samples were to be tested for the following parameters:

- Unconfined compressive strength (ASTM D-2166) to establish strength properties of the material used in engineering evaluation of the ability of the material to support heavy equipment and/or a cap.
- Unit weight (ASTM D-2937-83) to establish density properties of the material used in developing alternatives, e.g., cost analysis.

- pH (ASTM D-4972-89) to establish acidity/basicity properties of the material used in developing alternatives, e.g., those involving treatment.
- Triaxial compression (ASTM D-4767) to establish strength properties of the material used in engineering evaluation of the ability of the material to support heavy equipment and/or a cap.

From the Consolidation Area, 24 discrete soil samples were collected for VOC and SVOC analysis.

One composite was prepared from portions of samples from three discrete depths in the fill material from borings SM-1 to SM-4 and three discrete depths in the fill material from borings SM-5 and SM-6. One composite sample was prepared from soil borings SM-1 to SM-4 collected from the native material below the fill material. One composite was prepared from soil borings SM-5 and SM-6 collected from the native material below the fill material. Each of the composites was submitted to Quanterra Environmental Laboratory for pesticide, PCB, and total/TCLP metal analysis.

Fifteen discrete samples were collected from former Lagoons 3 and 4 for analysis of VOC and SVOC analysis, and one composite was prepared from portions of samples from the two discrete depths in the fill material in each of their two respective borings for analysis of pesticides, PCBs, and total/TCLP metals. Additionally, one composite was prepared from a portion of the two discrete sample points of the natural soils underlying former Lagoon 3; and one composite was prepared from a portion of the two discrete sample points of the natural soils underlying former Lagoon 4 for analysis of pesticides, PCBs, and total/TCLP metals.

Table 4-2 presents soil sample information such as soil sample depth intervals, geotechnical or chemical laboratory analyses and discrete versus composite samples.

Samples collected for VOC analysis were placed in the proper laboratory sample jar with minimum disruption to limit volatilization. The soil jar was filled to the top (no headspace) and immediately capped.

For the composite samples, a portion of each split-spoon sample was stored in a laboratory-prepared, clean glass jar in a cooler with ice until all sampling in the composite area was completed. After all sampling was completed in an area, the samples were removed from the cooler and the composite samples were prepared as follows. Approximately equal portions of each of the split-spoon samples to be used for each composite were placed in a decontaminated stainless steel pan and homogenized. A

sample of the composite soil was collected, placed in appropriately labeled laboratory containers, and stored in the sample shipping cooler awaiting shipment to a laboratory. This procedure was followed for each of the composite samples.

Two surficial soil samples were collected from areas of staining and odors as presented on Plate 1. The samples GL-SS-SS-1 and GL-SS-SM-8 were collected from the 0-1 foot interval using a clean hand auger and analyzed for VOCs, SVOCs, pesticides, PCBs, and total/TCLP metals.

The saturated zones encountered during drilling through the material in the Consolidation Area and Lagoon areas were sampled. Ground water was sampled from borings SM-1, SM-4, SM-8, and SM-9 through the augers using a bailer and analyzed for VOCs, SVOCs, metals, pesticides, and PCBs.

All sample analyses were performed as described in U.S. EPA SW-846. As part of the QA/QC program, a duplicate sample, field blank (equipment wash blank), and trip blank were incorporated into the stabilized material sampling event.

Cuttings generated from the borings performed in the Consolidation Area, former Lagoon 3 area, and former Lagoon 4 area were containerized in labeled 55-gallon drums. Each boring was backfilled with a bentonite/cement grout.

4.2.2

Phase I - Background Soil Sampling Procedures

The inorganic content of Ohio soils may vary considerably from site to site. Therefore, 16 background soil samples were collected and analyzed to provide a statistical basis for the identified inorganic constituents of concern.

Two soil samples were collected from each of eight locations (BG-1 to BG-8) shown on Plate 8. These samples were collected from 6-inch to 12-inch, and 18-inch to 24-inch depth intervals using a clean hand auger.

After collection, the soil sample was placed in a stainless steel bowl and homogenized. The homogenized soil was then placed in the appropriately labeled containers and stored in the sample shipping cooler. The soil samples were shipped to Quanterra Environmental Laboratory for total metals analysis.

Phase I - Hydrogeologic Characterization Sampling Procedures

In June and July 1996, a soil boring and monitoring well installation/sampling program was conducted to characterize the Site hydrogeology and to determine the extent of chemical impacts.

Soil Boring Advancement

The soil boring program consisted of hollow stem auger drilling and soil sampling to the top of the limestone bedrock at 13 locations (SB-1 to SB-13) around the Site (Plate 1). Throughout the soil boring program, split-spoon samples of the underlying soil were collected. These samples were characterized and logged in the field by a geologist and then were placed in clean, glass jars for storage and safekeeping. All soil samples collected were field screened for presence of volatile organics using an OVA. A portion of each split-spoon sample was placed in a clean glass jar sealed with aluminum foil and allowed to volatilize for five to ten minutes in a heated vehicle (minimum 70F) if the outside temperatures fell below 60F. The contents of the jar were then scanned for organic vapors by inserting the OVA probe through the aluminum foil and sampling the jar's headspace. The results of these tests are noted on the log of each boring.

Based on the results of the field screening, visual criteria and geologic characteristics, soil samples were selected for laboratory analysis of the appropriate indicator chemicals detected during the investigation of the material in the Consolidated Area, former Lagoon 3, and former Lagoon 4. As part of the QA/QC program, a duplicate sample, field blank (equipment wash blank), and trip blank were incorporated into the soil sampling event.

Monitoring Well Installation

Monitoring wells were installed in the limestone at three of the soil boring locations (MW-1/SB-2, MW-2/SB-5 and MW-3/SB-9) and in the unconsolidated materials in five of the borings (MW-4/SB-7, MW-5/SB-11, MW-6/SB-4, MW-7/SB-1 and MW-8/SB-6) at the locations indicated on Plate 1. For the shallow monitoring wells, the soil borings were advanced using hollow stem augers to the desired well depth and completed as described below.

For bedrock wells, the soil borings were advanced using hollow stem augers to the top of the clay unit. The augers were removed from the borehole and a 12-inch steel surface casing was grouted into place approximately 3 feet into the clay. Boring advancement using hollow stem auger drilling continued to bedrock. The augers were removed from

the borehole and rotary drilling techniques were used to drill approximately 3 to 4 feet into the bedrock. The drilling rods were removed and a 6-inch diameter steel surface casing was grouted into place approximately 4 feet into the bedrock. When the grout had cured (not less than 24 hours), a rotary drilling bit was used to continue to drill into bedrock and advance the borehole approximately 10 feet into the bedrock.

For each of the monitoring wells the following general well construction technique was used: 1) the wells were completed as a 2-inch diameter PVC monitoring well, 2) the wells have a 5 to 10-foot length of PVC well screen with a PVC riser attached, 3) clean quartz sand was placed around the well screen to serve as filter pack, 4) the sand was placed to a height of 2 feet above the top of the screen 5) the top of the filter sand pack was sealed with a two-foot thick layer of bentonite pellets, 6) the remainder of the borehole was filled with a bentonite/cement grout mixture to a height of 1.5 to 2 feet below the ground surface.

The top of the monitoring well casing extends at least two feet above land surface and is surrounded by a concrete apron extending from the ground surface to below the frost line (approximately 3 feet). A protective outer steel casing with locking cap was placed over the well and extends approximately 3 feet into the concrete apron. The apron and protective casing are surrounded by guard posts. All monitoring wells have padlocks and are keyed alike.

Following installation, elevations of the tops of the monitor well PVC casings were surveyed to within 0.01 inch to a point marked on the top edge of the casing.

All cuttings produced during soil boring and monitoring well installation were containerized in labeled 55-gallon drums and transported to an on-site staging area.

Monitoring Well Development

The wells were developed upon completion by surging and bailing the shallow wells using a disposable bailer and by pumping the bedrock wells using a Grundfos Redi-Flow pump until 10 well volumes were removed. The pH, specific conductance and temperature were recorded in the field notebook. In accordance with the EE/CA work plan, the monitoring wells were to be developed until the field parameters of pH, specific conductance, temperature and turbidity had stabilized for three consecutive readings or until 10 well volumes had been removed. For each of the monitoring wells, 10 well volumes of water had been removed for development. The water removed from the wells was containerized in

labeled 55-gallon drums. The pump was properly decontaminated following the procedures outline in the EE/CA Work Plan.

Monitoring Well Sampling

Following development of the monitor wells, the wells were allowed to stabilize for approximately 48 hours before sampling.

Ground water levels in each well were determined using an electric water level measuring device. The depth to water was measured from a spot marked on the top of the well casing. Depths to water have been converted to ground water elevations from which the hydraulic gradient and direction of flow have been interpreted (Section 3).

Prior to sampling, standing water in the wells was purged using dedicated Teflon bailers in order to obtain a sample that was representative of the in-situ ground water quality. The volume of water purged from each well was at least three times the volume of water standing in the wells. The volume of standing water was determined by subtracting the depth to water from the total well depth and multiplying the result by a constant for the well inside diameter. During the purging process field parameters of pH, temperature, and specific conductance were recorded (Appendix D).

If any of the wells purged dry before three water volumes were removed, the well was allowed to recover for a period of 30 minutes and purging continued, if possible, until at least one, preferably three, well volumes were removed.

Following purging, samples were collected from the wells using dedicated Teflon bailers. The wells were sampled in order from suspected lower impacted to higher impacted wells. The first sample volume was used to fill the laboratory supplied sample bottles for laboratory analysis of VOCs. Subsequent sample volume was used to fill laboratory supplies sample bottles for laboratory analysis of SVOCs, total (unfiltered) metals, pesticides and PCBs and used to analyze field parameters of temperature, pH, and specific conductance. As part of the QA/QC program, a duplicate sample, field blank (equipment wash blank), and trip blank were incorporated into the ground water sampling event.

Stabilized Material/Soil Sampling Analytical Results

Appendix E presents the tables of analytical results for the stabilized material soil samples collected during the soil boring program. The stabilized material soil samples were analyzed for VOCs, SVOCs, pesticide, PCBs and metals. Based on the results of the laboratory analyses, the following list provides the VOC, SVOC, pesticides and PCBs which were detected in the soil samples and the ones which were detected but estimated below the laboratory's detection limit. This list formed the list of indicator compounds which was used in the subsequent phase of investigation at the site.

VOLATILES

2-Butanone

Benzene

Toluene

Ethylbenzene

Xylenes

Acetone

4-methyl-2-pentanone

Styrene

Carbon Disulfide

Trichloroethene

Plus degradation products:

cis-1,2-DCE

trans-1,2-DCE

1,1-DCE

Vinyl Chloride

SEMIVOLATILES

Phenol

bis(2-ethylhexyl) phthalate

Isophorone

4-Methylphenol

2-Methylphenol

2,4 Dimethylphenol

Naphthalene

Butylbenzophthalate

1,4 Dichlorobenzene

1,2 Dichlorobenzene

1,2,4 Trichlorobenzene

2-Methylnaphthalene

Phenanthrene

Di-n-butylphthalate

PESTICIDES/PCBs

Aroclor 1254

Stabilized Material/Soil-Primary VOCs Detected

The primary VOCs detected in soil boring SM-1 were Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) and 2-butanone.

The primary VOCs detected in soil boring SM-2 were 4-methyl-2-pentanone, Toluene, Ethylbenzene, Styrene and Xylenes.

The primary VOCs detected in soil borings SM-3 and SM-6 were acetone, 4-methyl-2-pentanone, Toluene, and Xylenes. While the compounds detected in SM-6 generally decreased in concentration with depth, the concentrations of compounds detected in SM-3 remained generally consistent with depth.

The primary VOCs detected in soil borings SM-4 and SM-5 were acetone, 4-methyl-2-pentanone, Toluene, Ethylbenzene, and Xylenes.

The primary VOCs detected in soil borings SM-7 and SM-8 were acetone, 4-methyl-2-pentanone, and BTEX.

In most of the soil borings, VOCs generally decreased in concentration with depth; however, in general VOCs were present at low concentrations in the soil sample collected from the native soil below the stabilized material.

The primary VOC detected in soil borings SM-9 and SM-10 was acetone.

The primary VOCs detected in two 0-1 foot depth surface soil samples (SS-SS-1 and SS-SM-8) were BTEX.

Stabilized Material/Soil - Primary SVOCs Detected

The primary SVOCs detected in the stabilized material soil borings SM-1, SM-3, SM-5, SM-6, and SM-7 were Phenol and bis(2-ethylhexyl) phthalate. Each of these compounds generally decreased in concentration with depth, however at borings SM-3, SM-6, and SM-7 compounds were present in the soil samples collected from the native material.

The primary SVOCs detected in soil boring SM-2 were Phenol, 4-methylphenol, 2,4-Dimethylphenol, naphthalene, butylbenzyl phthalate, and bis(2-ethylhexyl) phthalate. Each of these compounds generally decreased in concentration with depth.

The primary SVOCs detected in soil boring SM-4 were Isophorone and bis(2-ethylhexyl) phthalate. Each of these compounds generally decreased in concentration with depth.

The primary SVOCs detected in soil boring SM-8 were Phenol, bis(2-ethylhexyl) phthalate, 2 methylphenol and 4-methylphenol. Each of these compounds generally decreased in concentration with depth, however they were present in the soil samples collected from the native material.

The primary SVOC detected in soil borings SM-9 and SM-10 and the two 0-1 foot surface soil samples was bis(2-ethylhexyl) phthalate.

Stabilized Material/Soil - Primary Pesticide/PCBs Detected

There were no pesticides or PCBs detected above the laboratory's detection limit in the composite stabilized material soil samples. The PCB Aroclor 1254 was detected at estimated concentrations in the composite stabilized material samples from borings SM-1 to SM-4 (5-7 feet) and SM-7 and SM-8 (7-9 feet) and in the surface soil sample SS-SS-1 (0-1').

Stabilized Material/Soil - Metals Detected

The primary metals detected above the laboratory's detection limit in the stabilized material soil samples were arsenic, cadmium, and chromium. Mercury and zinc were detected above the laboratory's detection limit in a limited number of samples.

The surface soil sample collected from SS-SS-1 (0-1') had the following metals detected above the laboratory's detection limit: arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc.

There were no metals detected above the laboratory's detection limit for each of the composite samples and surface samples analyzed for TCLP metals.

Stabilized Material Soil Sampling Geotechnical Results

As described above shelly tube samples were generally collected two feet below ground surface and at mid-depth at each boring location. The results of the geotechnical testing are described in Section 8.2.5.

Ground Water Sampling Analytical Results

Appendix E and Plate 9 present the VOC and SVOC analytical results for the water samples collected from the stabilized material soil borings.

The following information provides a summary of the primary VOCs, SVOCs, and pesticide/PCBs detected in the shallow, perched water samples collected from inside the soil borings:

SM-1	VOCs	Acetone=27,000 ug/L 4-methyl-2-pentanone=120,000 ug/L
	SVOCs	Phenol=44,000 ug/L
	Pesticides/PCBs	None Detected
SM-4	VOCs	Acetone=110,000 ug/L 4-methyl-2-pentanone=110,000 ug/L 2-Butanone=22,000 ug/L Toluene=10,000 ug/L Xylenes=19,000 ug/L
	SVOCs	Phenol=5,800 ug/L 4-methylphenol=910 ug/L Isophorone=530 ug/L bis(2-ethylhexyl) phthalate=4,100 ug/L
	Pesticides/PCBs	None Detected
	VOCs	Acetone=170,000 ug/L 4-methyl-2-pentanone=85,000 ug/L
	SVOCs	Phenol=320,000 ug/L
	Pesticides/PCBs	None Detected
SM-8	VOCs	Acetone=170,000 ug/L 4-methyl-2-pentanone=85,000 ug/L
	SVOCs	Phenol=320,000 ug/L
	Pesticides/PCBs	None Detected
SM-9	VOCs	4-methyl-2-pentanone=20 ug/L
	SVOCs	None Detected
	Pesticides/PCBs	None Detected

The metals (unfiltered) detected above the laboratory's detection limit in the water samples collected from the stabilized material soil borings are the following: arsenic, cadmium, chromium, copper, lead, nickel, zinc.

4.2.5 *Phase I - Background Soil Sampling Analytical Results*

The results of the metals analyses for the background soil samples are presented in Appendix F. The distributions and derived background concentrations were calculated for the background metals data at the site. Background concentrations were calculated using concentrations of metals detected above the laboratory's detection limit for the following:

- 0.5 to 1.0 feet (upper horizon)
- 1.5 to 2.0 feet (lower horizon)
- 0.5 to 2.0 feet (both horizons combined)

Distributions

The metals distributions were determined both graphically and by testing for normality using the Shapiro-Wilks "W-Test" as specified in the Ohio EPA RCRA Closure Guidance. If any data set failed the W-Test, the test on the natural logarithm was performed.

Based primarily on the Shapiro-Wilks statistics and to a lesser extent on the graphical analysis, distributions were assessed as either:

- Normal, indicating that the data as collected displayed a normal distribution
- Log-Normal, indicating that the ln of the collected data was found to be normally distributed, or
- Other, indicating that neither the real or transformed data displayed normality. This occurred in the full data set (0.5 to 2.0 feet) for chromium, cadmium and copper. In each case, the graphical output indicated that the transformed data was slightly more normally distributed, so that data was used to calculate background concentrations.

The calculated metals background concentrations are presented in Appendix G.

4.2.6 Phase I - Hydrogeologic Characterization Sampling Analytical Results

Appendix E and Plate 10 present the VOC and SVOC analytical results for the soil samples collected from the soil borings.

The following information provides a summary of the primary VOCs, SVOCs, and pesticide/PCBs detected in the soil samples analyzed from the soil boring advancement.

Soil-Primary VOCs Detected

The only VOC detected in soil borings SB-1 and SB-4 was 4-methyl-2-pentanone. This compound was detected at shallow depths (i.e. < 10 feet) in each of these borings.

The only VOCs detected in soil boring SB-2 were acetone and 4-methyl-2-pentanone. These compounds were detected at shallow depths (i.e. < 10 feet) in each of these borings and were not detected above the laboratory's detection limit in the 30-32 foot sample interval.

The only VOC detected in soil borings SB-9, SB-10, and SB-12 was Benzene. This compound was detected at shallow depths (i.e. < 10 feet) in each of the borings.

The primary VOCs detected in soil boring SB-11 were Toluene, Ethylbenzene and Xylenes. These compounds were detected in the 0-2 foot sample interval.

There were no VOCs detected above the laboratory's detection limit in soil borings SB-3, SB-5, SB-6, SB-7, SB-8 and SB-13.

Soils - Primary SVOCs Detected

The primary SVOC detected in soil borings SB-1, SB-2, SB-4 and SB-12 was Phenol. This compound was detected at shallow depths (i.e. < 10 feet) in each of the borings. 2-methylphenol was also detected in SB-12 in the 6-8 foot sample interval.

The primary SVOC detected in soil boring SB-5 was bis(2-ethylhexyl) phthalate. This compound was detected in the 6-8 foot sample interval.

There were no SVOCs detected above the laboratory's detection limit in soil borings SB-3, SB-6, SB-7, SB-8, SB-9, SB-10, SB-11 and SB-13.

Soil - Primary Pesticide/PCBs Detected

There were no pesticides or PCBs detected above the laboratory's detection limit in the soil samples. The PCB Aroclor 1254 was detected at an estimated concentration in the soil sample from boring SB-11 (0-2 feet).

Ground Water Sampling Analytical Results

Appendix E and Plate 9 present the VOC and SVOC analytical results for the ground water samples collected from the monitoring wells.

The following information provides a summary of the primary VOCs, SVOCs, pesticide/PCBs, and total metals (unfiltered) detected in the water samples collected from the monitoring wells:

MW-1 Bedrock Well

VOCs	Acetone=4.1 J
SVOCs	None Detected
Pesticides/PCBs	None Detected
Metals*	None Detected

MW-2 Bedrock Well

VOCs	Acetone=13J ug/L
SVOCs	bis-2-ethylhexyl phthalate=2.2J ug/L
Pesticides/PCBs	None Detected
Metals*	Lead=0.004 mg/L

MW-3 Bedrock Well

VOCs	Acetone=37 ug/L, 4-methyl-2-pentanone=3.2J ug/L
SVOCs	bis-2-ethylhexyl phthalate=7.4J ug/L
Pesticides/PCBs	None Detected
Metals*	Lead=0.0044 mg/L

Well MW-3 was resampled in January 1997 with the following results, (the acetone concentration was estimated below the laboratory's detection limit):

MW-3 Bedrock Well

VOCs	Acetone=480 J ug/L
SVOCs	None Detected
Pesticides/PCBs	None Detected

MW-4 Shallow Well

VOCs	Benzene=9.1 ug/L, Acetone=11J ug/L
SVOCs	Fluoranthene=10 ug/L
Pesticides/PCBs	None Detected
Metals*	Arsenic=0.025 mg/L
	Chromium=0.035 mg/L
	Copper=0.057 mg/L
	Lead=0.026 mg/L
	Nickel=0.074 mg/L
	Zinc=0.18 mg/L

MW-5 Shallow Well

VOCs	Acetone=1,600 ug/L
	Benzene=110 ug/L
	4-methyl-2-pentanone=260 ug/L
SVOCs	Phenol 180J ug/L
Pesticides/PCBs	None Detected
Metals*	Arsenic=0.034 mg/L
	Chromium=0.027 mg/L
	Copper=0.038 mg/L
	Lead=0.016 mg/L
	Nickel=0.063 mg/L
	Zinc=0.14 mg/L

MW-6 Shallow Well

VOCs	4-methyl-2-pentanone=12,000 ug/L Acetone=24,000J ug/L, 2-Butanone=470J ug/L
SVOCs	Phenol=36,000 ug/L
Pesticides/PCBs	None Detected
Metals*	Arsenic=0.073 mg/L Chromium=0.014 mg/L Lead=0.0074 mg/L Zinc=0.072 mg/L

MW-7 Shallow Well

VOCs	Acetone=58,000 ug/L, 2-Butanone=1,500J ug/L 4-methyl-2-pentanone=30,000 ug/L
SVOCs	Phenol=9,300 ug/L
Pesticides/PCBs	None Detected
Metals*	Arsenic=0.16 mg/L Cadmium=0.0047 mg/L Cobalt=0.065 mg/L Chromium=0.063 mg/L Copper=0.16 mg/L Lead=0.067 mg/L Nickel=0.19 mg/L Zinc=0.40 mg/L

MW-8 Shallow Well

VOCs	Acetone=7.8J ug/L
SVOCs	None Detected
Pesticides/PCBs	None Detected
Metals*	Arsenic=0.044 mg/L Cadmium=0.0079 mg/L Cobalt=0.095 mg/L Chromium=0.10 mg/L Copper=0.29 mg/L Lead=0.096 mg/L Nickel=0.21 mg/L Zinc=0.69 mg/L

* unfiltered samples

4.3

PHASE II GEOPROBE BORING ADVANCEMENT

Based on the analytical results obtained from the Phase I soil and ground water sampling program, additional soil and ground water sampling was recommended in an effort to evaluate the extent of impact to the soil and the shallow ground water.

4.3.1

Phase II - Geoprobe Boring Sampling Procedures

Geoprobe borings (GB-1 to GB-17) were installed at the locations indicated on Plate 1. Soil samples were collected continuously from the ground surface to the depth at which ground water was encountered in each of the Geoprobe borings.

A sample of the ground water was collected from each of the boring locations with the exception of borings GB-16 and GB-17, which did not produce sufficient quantities of water for sampling. The water samples were collected from the borings using disposable tygon tubing and a peristaltic pump.

Each of the soil and ground water samples was analyzed in the field for VOCs/SVOCs on the list of indicator compounds utilizing an on-site mobile laboratory equipped with a gas chromatograph/mass spectrometer. Ten percent of the soil and ground water samples were submitted to Quanterra Environmental Laboratory for confirmation laboratory analysis of VOCs/SVOCs. Selected soil and ground water samples were submitted to Quanterra for analysis of metals (unfiltered).

The on-site mobile laboratory provided real-time analytical data in the field. Based on the data obtained from the mobile lab, additional Geoprobe borings were added to the field effort in an effort to further delineate the soil and ground water VOC/SVOC impacts. A total of 17 Geoprobe borings were installed.

4.3.2

Phase II - Geoprobe Sampling Analytical Results

The tables of analytical results for the soil and ground water analyzed in the field by the mobile laboratory and submitted to Quanterra for confirmation analysis are presented in Appendix H. Table 4-3 provides a summary of the VOC and SVOC data for the soil and ground water samples collected using the Geoprobe sampling technique. The primary metals detected in the soil samples were cadmium, chromium, copper, nickel, and zinc. The primary metals (unfiltered) found in the water samples were cadmium, chromium, copper, lead, nickel, and zinc.

Plate 9 presents the VOC and SVOC analytical results for the ground water samples collected from the Geoprobe borings. Plate 11 presents the VOC and SVOC analytical results for the soil samples collected from the Geoprobe borings.

4.4 PHASE III - STREAM SURFACE WATER/SEDIMENT SAMPLING

4.4.1 Phase III - Stream Sampling Procedures

In July 1997, surface water and sediment samples were collected at four locations along the unnamed drainage ditch located east of the lagoons (Plate 8). Sampling was performed to confirm the presence or absence of releases to surface water and/or sediment from the Site.

Both a surface water and sediment sample were collected at each location. Samples were collected beginning at the downstream location and moving progressively upstream. Surface water samples from the unnamed ditch were collected directly into the laboratory sample bottles. The water samples were collected from a location mid-stream and mid-depth in order to minimize the inclusion of sediment. All surface water sample locations were subjected to field tests for temperature, pH, Eh, conductivity, and dissolved oxygen. The sediment samples were collected using a decontaminated stainless steel trowel.

Immediately following sample collection, the containers were stored in sample holders provided by the laboratory. The samples were kept cool by being packed with ice. Before shipment, the containers were packed securely with a packing material such as bubble-wrap. The coolers were shipped via overnight courier service to the laboratory (Quanterra Environmental Laboratory) under proper chain-of-custody procedures.

A wooden stake, marked with the sample identification number, was installed at each surface water/sediment sampling location to facilitate subsequent location of the sampling point, if necessary. Flow was estimated by measuring width and average depth and average velocity.

Each location was analyzed for the chemical indicator parameters. As part of the QA/QC program, a duplicate sample, field blank (equipment wash blank), and trip blank were incorporated into the surface water/sediment sampling event.

4.4.2 Phase III - Stream Sampling Analytical Results

The tables of analytical results for the sediment and surface water samples from the unnamed ditch located to the east of the lagoons are presented in Appendix I. There were no VOCs or SVOCs detected above the laboratory's detection limit for the four surface water and sediment samples.

There were no metals detected above the laboratory's detection limit for the four ditch surface water samples. Chromium, nickel and zinc were detected above the laboratory's detection limit in the four ditch sediment samples.

The grain size analysis results are presented in Appendix I. As indicated by the particle size distribution tests, the sediment in the unnamed ditch consists of a fine to coarse-grained silty sand.

In general, the ditch width and depth increased and the water velocity decreased with movement from downstream (SW/SED-1) to upstream (SW/SED-4). The dimensions of the ditch at SW/SED-1 were width=2'4" and depth=2 inches and at SW/SED-4 were width=5'6" and depth=3.5 inches. The surface water velocity in the ditch decreased from approximately 0.98 ft/sec. at SW/SED-1 to approximately 0.1 ft/sec at SW/SED-3.

4.5 SUPPLEMENTAL FIELD INVESTIGATION

4.5.1 Supplemental Field Investigation Sampling Procedures

In November 1998, six additional shallow monitoring wells were installed in the field surrounding the former lagoons to further define conditions in the shallow saturated zone.

Monitoring Well Installation

Monitoring well installation consisted of hollow stem auger drilling and soil sampling to the shallow saturated zone at six locations (MW-9 to MW-14) in the fields around the Site (Plate 1). During drilling, split-spoon samples of the underlying soil were collected. These samples were characterized and logged in the field by a geologist. All soil samples collected were field screened for presence of volatile organics using an OVA.

For the each of the monitoring wells the following general well construction technique was used: 1) the wells were completed as a 2-inch diameter PVC monitoring well, 2) the wells have a 10-foot length of PVC well screen with a PVC riser attached, 3) clean quartz sand was placed around the well screen to serve as filter pack, 4) the sand was placed to a height of approximately 1 foot above the top of the screen 5) the top of the filter sand pack was sealed with a two-foot thick layer of bentonite pellets, 6) the remainder of the borehole was filled with a

bentonite/cement grout mixture to a height of 1.5 to 2 feet below the ground surface.

The top of the monitoring well casing extends at least two feet above land surface and is surrounded by a concrete apron extending from the ground surface to below the frost line (approximately 3 feet). A protective outer steel casing with locking cap was placed over the well and extends approximately 3 feet into the concrete apron. All monitoring wells have padlocks and are keyed alike.

Following installation, elevations of the tops of the monitor well PVC casings were surveyed to within 0.01 inch to a point marked on the top edge of the casing.

All cuttings produced during soil boring and monitoring well installation were containerized in labeled 55-gallon drums and transported to an on-site staging area.

Monitoring Well Development

The wells were developed upon completion by surging and bailing using a disposable bailer until 10 well volumes were removed. The pH, specific conductance and temperature were recorded in the field notebook. In accordance with the EE/CA work plan, the monitoring wells were to be developed until the field parameters of pH, specific conductance, temperature and turbidity had stabilized for three consecutive readings or until 10 well volumes had been removed. For each of the monitoring wells, 10 well volumes of water had been removed for development. The water removed from the wells was containerized in labeled 55-gallon drums.

Monitoring Well Sampling

Ground water levels in each well were determined using an electric water level measuring device. The depth to water was measured from a spot marked on the top of the well casing. Depths to water have been converted to ground water elevations from which the hydraulic gradient and direction of flow have been interpreted (Section 3).

Prior to sampling, standing water in the wells was purged using disposable Teflon bailers in order to obtain a sample that was representative of the in-situ ground water quality. The volume of water purged from each well was at least three times the volume of water standing in the wells. The volume of standing water was determined by subtracting the depth to water from the total well depth and multiplying

the result by a constant for the well inside diameter. During the purging process field parameters of pH, temperature, and specific conductance were recorded (Appendix D).

Following purging, samples were collected from each of the existing and the newly installed monitoring wells using disposable Teflon bailers. The wells were sampled in order from suspected lower impacted to higher impacted wells. The first sample volume was used to fill the laboratory supplied sample bottles for laboratory analysis of VOCs. Subsequent sample volume was used to fill laboratory supplied sample bottles for laboratory analysis of SVOCs, total (unfiltered) metals, pesticides and PCBs and used to analyze field parameters of temperature, pH, and specific conductance. As part of the QA/QC program, a duplicate sample and a trip blank were incorporated into the ground water sampling event.

4.5.2 *Supplemental Field Investigation Sampling Analytical Results*

Appendix K presents the table of analytical results for the ground water samples collected from the existing and the newly installed monitoring wells during the November 1998 supplemental field investigation. In addition, Plate 9 presents the results of the ground water sampling.

All volatile organic compounds (VOCs) and semi-volatile organic compounds analyzed from the newly installed wells were not detected above the sample reporting limits except for two VOCs. In addition, metal results are reported at concentrations below maximum contaminant levels.

Acetone was detected at low estimated concentrations in monitoring wells MW-9 (16 J ug/L), MW-10 (10 J ug/L), MW-11 (11 J ug/L) and MW-12 (19 J ug/L). Acetone was detected in monitoring well MW-13 at a concentration of 4,000 ug/L during the November 1998 sampling event. Monitoring well MW-13 was resampled on January 20, 1999 and on January 29, 1999. Analytical results indicated that no acetone was detected for each resampling event. As indicated in Section 3, the flow direction the water in the shallow saturated zone near monitoring well MW-13 appears be very sensitive to seasonal water elevations. During November 1998 ground water elevation data indicates a mounding effect of the shallow saturated zone near monitoring well MW-6. During this time period, flow in that saturated zone may radiate in all directions (including toward shallow well MW-13) from the area of MW-6. The flow in the shallow saturated zone is sensitive to seasonal water elevation fluctuations. However, it appears that the flow direction of the shallow saturated zone is generally toward the northwest, west and southwest.

4-methyl-2-pentanone was detected at extremely low estimated concentrations in newly installed monitoring wells MW-9 (3.7 J ug/L) and MW-12 (15 J ug/L).

Lead was detected at concentrations which exceed the Action Level (Drinking Water Health Level) of 0.015 mg/L in the newly installed wells MW-9, MW-13 and MW-14. However, the action level for lead is set at the drinking water tap. The water samples collected from the newly installed shallow monitoring wells were collected using a bailer and are total metals concentrations not dissolved metals concentrations. As stated in Section 3, the shallow saturated zone will not be used for potable purposes.

The following information provides a summary of the primary VOCs, SVOCs, and total metals detected in the water samples collected from the monitoring wells during the November 1998 supplemental field investigation:

MW-1 Bedrock Well

VOCs	None Detected
SVOCs	Phenol=2.8 J ug/L
Metals*	Lead=0.0052 mg/L
	Zinc=0.055 mg/L

MW-2 Bedrock Well

VOCs	None Detected
SVOCs	None Detected
Metals*	Lead=0.0099 mg/L
	Zinc=0.080 mg/L

MW-3 Bedrock Well

VOCs	None Detected
SVOCs	None Detected
Metals*	Lead=0.014 mg/L
	Zinc=0.061 mg/L

MW-4 Shallow Well

VOCs	Benzene=1.6 J ug/L
	Acetone=8.3 J ug/L
SVOCs	None Detected
Metals*	Arsenic=0.018 J mg/L
	Chromium=0.020 mg/L
	Copper=0.038 mg/L
	Lead=0.013 mg/L
	Zinc=0.15 mg/L

MW-5 Shallow Well

VOCs Acetone=500 ug/L
 Benzene=63 ug/L
 4-methyl-2-pentanone=80 J ug/L
 2-Butanone=77 J ug/L
 Ethylbenzene=5.7 J ug/L
 Toluene=8.5 J ug/L
 Xylenes=11 J ug/L
SVOCs None Detected
Metals* Arsenic=0.018 J mg/L
 Chromium=0.007 mg/L
 Nickel=0.040 mg/L
 Zinc=0.13 mg/L

MW-6 Shallow Well

VOCs 4-methyl-2-pentanone=600 ug/L
 Acetone=1,400 ug/L
 Benzene=18 J ug/L
SVOCs Phenol=1,400 ug/L
Metals* Arsenic=0.066 J mg/L
 Copper=0.041 mg/L
 Zinc=0.063 mg/L

MW-7 Shallow Well

VOCs Acetone=19 J ug/L
 Benzene=23 ug/L
SVOCs None Detected
Metals* Arsenic=0.086 J mg/L
 Copper=0.028 mg/L
 Lead=0.0033 mg/L
 Zinc=0.11 mg/L

MW-8 Shallow Well

VOCs Acetone=6.3 J ug/L
 Benzene=1.3 J ug/L
SVOCs None Detected
Metals* Arsenic=0.039 J mg/L
 Chromium=0.0088 mg/L
 Copper=0.026 mg/L
 Lead=0.0088 mg/L
 Zinc=0.12 mg/L

MW-9 Shallow Well

VOCs Acetone=16 J ug/L
 4-methyl-2-pentanone=3.7 J ug/L
SVOCs None Detected
Metals* Arsenic=0.016 J mg/L
 Chromium=0.016 mg/L

Copper=0.035 mg/L
Lead=0.015 mg/L
Zinc=0.13 mg/L

MW-10 Shallow Well

VOCs Acetone=10 J ug/L
SVOCs None Detected
Metals* Chromium=0.016 mg/L
Lead=0.0095 mg/L
Zinc=0.095 mg/L

MW-11 Shallow Well

VOCs Acetone=11 J ug/L
SVOCs None Detected
Metals* Arsenic=0.011 J mg/L
Chromium=0.012 mg/L
Nickel=0.040 mg/L
Lead=0.011 mg/L
Zinc=0.11 mg/L

MW-12 Shallow Well

VOCs Acetone=19 J ug/L
4-methyl-2-pentanone=15 J ug/L
SVOCs None Detected
Metals* Chromium=0.023 mg/L
Copper=0.029 mg/L
Lead=0.014 mg/L
Zinc=0.13 mg/L

MW-13 Shallow Well

VOCs Acetone=4,000 ug/L
SVOCs None Detected
Metals* Arsenic=0.039 J ug/L
Chromium=0.039 mg/L
Copper=0.080 mg/L
Nickel=0.084 mg/L
Lead=0.037 mg/L
Zinc=0.24 mg/L

Resampling of Shallow Well MW-13 on January 20, 1999 and January 29, 1999 for VOCs indicated no VOCs were detected.

MW-14 Shallow Well

VOCs None Detected
SVOCs None Detected
Metals* Arsenic=0.027 J ug/L
Chromium=0.023 mg/L
Copper=0.065 mg/L

Nickel=0.066 mg/L

Lead=0.029 mg/L

Zinc=0.21 mg/L

* unfiltered samples

4.6

SUMMARY OF QUALITY ASSURANCE REPORTS

Appendices E, H, I, and K provide the detailed analytical quality assurance reports (QARs) for each of the sampling events. This section provides a summary of the information provided in five QARs for all water and soil/sediment samples, and associated quality control samples collected from 9 April 1996 through 11 November 1998 at the site.

The organic analytical data and their associated field quality control data were validated or qualified using general guidance provided by the "National Functional Guidelines for Organic (and Inorganic) Data Review", USEPA, 2/94 (and 2/94).

The organic analyses were performed according to the protocols specified in "Test Methods for Evaluating Solid Waste", SW-846, Third Edition, November 1986, updated July 1992. The inorganic sample analyses were performed according to the protocols specified in "Test Methods for Evaluating Solid Waste", SW-846, Third Edition, September 1994.

The data reported within the five QARs have met the analytical requirements, as specified in the above guidance documents and protocols, and are of sufficient quality and are considered useable for purposes of site characterization and risk assessment. All constituents that were detected in at least one sample of each medium were included in the risk assessment. The following sections outline the data qualifiers that were included with the data.

4.6.1

Organic Data Qualifiers

The positive results reported for volatile organic compounds: acetone, methylene chloride, toluene, and 4-methyl-2-pentanone; and semivolatile organic compounds, bis (2-ethylhexyl)phthalate and phenol are considered qualitatively invalid in some ground water and soil samples due to the levels at which these specified compounds were present in the associated laboratory method and/or field blanks. The qualitatively invalid results have been marked with "B" qualifiers on the data summary table for these compounds in the specified ground water and soil samples.

The positive results and/or quantitation limits for volatile and semivolatile organic compounds in some samples have been marked with

"J" qualifiers on the data summary tables to indicate that they are quantitative estimates. The positive results and/or quantitation limits for these compounds are considered quantitative estimates for any one of several possible reasons: poor relative response factors (RRF) precision in the initial and/or in the continuing calibration were reported in the standards associated with these compounds, the area counts for the internal standard compounds used for quantitation and/or surrogate recoveries were outside the quality control limits for these samples, the sample extraction/reextraction was performed outside the allowable holding times, the blind duplicate precision criteria was not met, or the reported compounds were qualitatively identified at concentrations below their respective method quantitation limits (MQLs).

Several ground water and soil samples were analyzed for volatile and semivolatile organic compounds (VOCs and SVOCs) at initial dilutions because of the suspected chromatographic interferences present in these samples. The initial dilutions were required to prevent saturation of the instrument and to allow adequate chromatographic resolution and quantitation of the compounds within the linear calibration range of the instrument. Higher quantitation limits have resulted for volatile and semivolatile organic compounds which were not detected in these samples.

4.6.2

Inorganic Data Qualifiers

The positive results and/or detection limits for metals in some samples have been marked with "J" qualifiers on the data summary tables to indicate that they are quantitative estimates. The positive results and/or detection limits for these metals in these samples are considered quantitative estimates for any one of several possible reasons: there was a negative response for these metals in the associated laboratory initial and/or continuing calibration blanks (ICBs and/or CCBs), the associated matrix spike recoveries were outside the established quality control (QC) limits, the ICP serial dilution analysis results associated with these metals exceeded the established precision criteria of ten percent (10%) difference, or the blind duplicate precision criteria was not met.

A Streamlined Risk Evaluation (SRE) was performed for the Greiner's Lagoon Site to assess potential risks to human health and the environment. The SRE consisted of the following components:

- Development of a site conceptual model (SCM),
- Evaluation of analytical sampling data,
- Toxicity Assessment,
- Risk Characterization, and
- Uncertainty Analysis.

An evaluation of potential ecological risk was also conducted. The preliminary ecological risk assessment is provided in Section 6.0.

5.1**SITE CONCEPTUAL MODEL**

A Site Conceptual Model (SCM) was developed to identify the potential exposure pathways by which human receptors could be exposed to constituents at the site. The SCM allows an evaluation of the likelihood, magnitude and frequency of exposure to the constituents at the site. Using the conceptual model, the exposure pathways requiring evaluation in the risk assessment were identified. To qualify for evaluation, a pathway must include the following four elements:

- A source and mechanism of constituent release to the environment;
- A transport medium by which the released constituent may reach a receptor (e.g., ground water);
- A point of potential contact where the human receptor may be exposed to contaminated medium (e.g., individual accesses the site and contacts the contaminated medium); and
- An exposure route (e.g., ingestion, dermal contact, inhalation).

To determine whether a complete exposure pathway exists, the physical characteristics of the site were examined to identify potential pathways by which human receptors may be exposed to constituents at the site. Exposure scenarios were then developed based on demographics, land use, and general human behavior patterns. For the complete pathways, exposure dose estimates were calculated for each actual and potential exposure pathway and receptor population.

5.1.1

Potential Human Receptors and Pathways of Exposure

Demographics and land use were evaluated to assess present and potential future populations living, working, or otherwise spending time at or in the area of the Greiner's Lagoon site. The purpose of this analysis was to assess the likelihood of human exposure to site constituents by various populations, including sensitive subpopulations. It should be noted that human access to the area surrounding the site is limited and that frequent contact with constituents that may be present at the site will not occur on a daily basis. Further, the opportunity for exposure to affected soil is significantly reduced because the inactive site, consisting of four former lagoons, has been dewatered, partially stabilized, filled and covered with a layer of clean soil. Nevertheless, hypothetical human exposure scenarios for the current and future use of the site were evaluated in this assessment.

As shown in Table 5-1, three human receptor populations, and media that each population may have contact with, were identified to assess potential current or future exposures at the site. These human receptor populations consisted of future construction workers, local residents and occasional trespassers. This table also provides the rationale for the elimination of exposure pathways that are not addressed in this assessment. Each of these populations is discussed below.

5.1.1.1

Future Construction Worker

The future construction worker scenario was evaluated for both on-site and off-site exposures with affected media. It is important to note that should future construction activities take place, such as cap enhancement, adherence to appropriate health and safety requirements for personal protection will be enforced, thus further reducing the potential for exposure. However for purposes of this assessment, potential exposures to soil, ground water, surface water and sediment were conservatively evaluated for the future construction worker.

As outlined in Table 5-1, future construction workers may be exposed to off-site and on-site soil and perched ground water (both on- and off- site), during proposed construction activities. As noted above, affected on-site soils are located beneath fill material and clean soil. Off-site soils, where limited impacts may have occurred, were also considered. Ingestion, dermal contact and inhalation routes of exposures were considered for the future construction worker who may be exposed to off- and on-site soils. Exposure with perched ground water may occur if water accumulates in excavations or trenches during future construction activities at the site.

For this evaluation, dermal contact and inhalation exposures were evaluated for the construction worker.

Future construction workers may also contact affected surface water and sediment in the off-site drainage ditch. Dermal contact with surface water and sediment were included to assess these potential pathways of exposure. Ingestion of surface water and sediment are not expected to occur during planned construction activities, thus were not included within the assessment.

5.1.1.2 *Off-Site Residents*

Future residential use of this property is very unlikely. The area surrounding the site is expected to remain rural/agricultural as there are no known plans for redevelopment of this property. For these reasons, exposures to on-site soils by residents are not expected and were not included in the assessment. However, residential exposures to off-site soils were included. Ingestion, dermal contact and inhalation routes of exposures were considered for off-site residents who may be exposed to off-site soils.

It is plausible that residential exposure may exist with the bedrock aquifer, which serves as a source of drinking water in the area. To provide a conservative estimate of this ground water use, the residential scenario was evaluated. This assessment assumed that residents with water supply wells in a potentially impacted area would ingest constituents when drinking the water, as well as dermal contact and inhalation of the vapors that may occur during showering activities.

5.1.1.3 *Trespasser*

To conservatively estimate the risk to off-site receptors that may contact on-site soil, a trespasser scenario was included. Ingestion, dermal contact and inhalation routes of exposures were considered for trespassers who may be exposed to on-site soils.

The trespasser was also evaluated for potential risks that may be associated with ingestion and dermal contact with affected surface water and sediment.

5.1.2 *Exposure Evaluation*

Standard USEPA equations (USEPA, 1989a) were used to estimate exposure doses received by the receptor populations for all above described scenarios. The exposure parameters, described below, were

applied to these equations. The specific algorithms used to estimate the exposure dose for each medium and each receptor, in addition to the exposure parameters used for each exposure scenario are provided in the tables discussed in Section 5.4.

Values used for exposure parameters generally reflect reasonable maximum assumptions. Where USEPA guidance (USEPA, 1989; 1991a) was specific, these values were adopted. If specific inputs were not recommended in these documents, the *Exposure Factors Handbook* (USEPA 1997), the *Standard Default Exposure Factors* guidance (USEPA, 1991b) and *Dermal Exposure Assessment* guidance (USEPA, 1992) were consulted as additional resources to develop realistic exposure assumptions. Additionally, professional judgment was used to develop the exposure assumptions when site-specific conditions were considered. The exposure parameters considered for each receptor population are briefly described below.

5.1.2.1

Future Construction Worker

Where appropriate, standard exposure assumptions were utilized for the evaluation of the on-site construction worker. These exposure assumptions represent the realistic exposure that may occur under routine construction worker conditions. Thus, the results of this assessment provide a very conservative estimate of the actual risk that may be present at the site.

The exposure scenario for construction workers assumed a 70-Kg adult worker and a one year duration of exposure (USEPA, 1991a). The frequency of exposure with on-site and/or off-site soils was assumed to be 60 days/year, which conservatively represents the anticipated maximum time that may be required to complete proposed construction activities at the site. The maximal soil ingestion rate of 480 mg/day was used. Dermal contact with soil assumed an estimated skin surface area of 5,300 cm²/day which represents contact with the skin surface area of the head, neck, arms and hands (USEPA, 1995).

Construction workers may also contact perched ground water that may accumulate in excavations or trenches. The frequency of exposure to perched ground water was assumed to be 20 days, which represents one-third of the maximum time (60 days) that may be required to complete proposed construction activities. Dermal contact with perched water assumed an estimated skin surface area of 7,000 cm²/day which represents contact with the skin surface area of the hands, forearms, lower legs, and feet (USEPA, 1997). During excavation activities, inhalation of volatilized constituents present in the perched water may occur.

Procedures used to derive volatile air emissions and resultant air concentrations that may occur during excavation activities are described in the following section. Potential dermal exposures to surface water and sediment from the ditch were also evaluated for the construction worker, should construction activities occur in the area of the off-site ditch.

Volatilization from Shallow Ground Water in a Construction Trench

Estimation of the emission rate of volatile organic constituents from shallow ground water in a construction trench was made following the methods presented in *Superfund Exposure Assessment Manual* (SEAM; USEPA, 1988). This method was developed by Mackay and Leinonen, and relates the emission rate to an overall mass transfer coefficient, as shown below:

$$E_i = K_i \times C_s \times A$$

where:

E_i = Emission Rate (mg/second)

K_i = Overall Mass Transfer Coefficient (cm/second)

C_s = Contaminant Liquid Phase Concentration (mg/cm³)

A = Area (cm²)

Emission rates were developed for two separate scenarios, the on-site construction worker and the off-site construction worker. The area utilized for both scenarios was based on an assumed trench area of 20 feet in length and 5 feet wide (i.e., 6 meters by 1.5 meters). Thus, an area of 9 square meters was used in the emission rate calculations.

The overall mass transfer coefficient is calculated as follows:

$$K_i^{-1} = K_{iL}^{-1} + ((R \times T)/(H_i \times K_{iG}))$$

where:

K_{iL} = Liquid Phase Mass Transfer Coefficient (cm/second)

R = Ideal Gas Law Constant (8.2×10^{-5} atm-m³/mole-°K)

T = Temperature (298 °K)

H_i = Henry's Law Constant for Compound i (atm-m³/mole)

K_{iG} = Gas Phase Mass Transfer Coefficient (cm/second)

K_{iL} and K_{iG} for constituent i were estimated from measured values for known constituents (i.e., oxygen and water vapor) as follows:

$$K_{iL} = (MW_{O_2}/MW_i)^{0.5} \times (T/298) \times (k_L, O_2)$$

$$K_{iG} = (MW_{H_2O}/MW_i)^{0.335} \times (T/298)^{1.005} \times (k_G, H_2O)$$

where:

MW_{O_2} = Molecular Weight of Oxygen (32 g/mole)

MW_{H_2O} = Molecular Weight of Water (18 g/mole)

MW_i = Molecular Weight of Compound i (g/mole)

T = Temperature (298 °K)

k_L, O_2 = Liquid Phase Mass Transfer Coefficient for Oxygen at 25°C (0.0061 cm/second; L. Thibodeaux, 1979)

k_G, H_2O = Gas Phase Mass Transfer Coefficient for Water Vapor at 25°C (0.833 cm/second; L. Thibodeaux, 1979)

Emission rates were calculated for volatile constituents of potential concern in ground water, and the results of these calculations are presented on Tables 5-2 and 5-3 for the off-site construction worker and on-site construction worker exposure scenarios, respectively.

Calculation of Ambient Air Concentrations

Ambient air concentrations of volatile organic constituents were modeled to evaluate potential exposures to these constituents via inhalation. To provide ambient air concentrations for constituents volatilizing from shallow ground water in a construction trench, a simple box model was used to simulate constituent dispersion. The box model allowed estimation of ambient air concentrations within a confined space, as follows:

$$C_a = \frac{E_i}{LS \times V \times MH}$$

where:

- C_a = Ambient Air Concentration (mg/m³)
- E_a = Total Emission Rate for the area (mg/second)
- LS = Length of side perpendicular to the wind (meters)
- V = Air ventilation in trench (meters/second)
- MH = Mixing Height before being inhaled (meters)

This model conservatively assumed a constant emission rate, regardless of temperature, precipitation, etc. The LS term was assumed to be 3 meters which is the square root of the area of the trench. For both exposure scenarios, an average wind speed of 4.2 meters per second was used. This wind speed is the mean annual wind speed for Toledo, Ohio. The height of the box was assumed to be the height of the receptor above the trench. The trench was assumed to be 3 feet deep. Thus, the mixing height was assumed to be approximately 1 meter (i.e., 3 feet).

These ambient air concentrations were used as the exposure point concentrations EPCs for evaluation of inhalation exposures for the two scenarios discussed above. The resulting EPCs are shown on Tables 5-4 and 5-5 for the off-site construction worker and on-site construction worker exposure scenarios, respectively.

5.1.2.2 *Off-Site Residents*

Consistent with the approach taken for the future on-site construction worker, standard exposure assumptions were used for residential exposures. These exposure assumptions represent the reasonable maximum exposure that may occur under typical residential conditions; however, such exposures at the site are not expected to occur. The results of this assessment provide a very conservative estimate of the actual risk that may be present should residential receptors (e.g., adults and children) use affected bedrock ground water as a residential water supply. Additionally, potential exposures with off-site soils were also evaluated for residential receptors.

The hypothetical scenario for exposure to bedrock ground water and contact with affected off-site soil by future on-site residents was based on an adult weight of 70 kg and a child (age 1-6) weight of 15 kg (USEPA, 1989). The exposure duration for the adult was 30 years (for ground

water) and 24 years for soil. The exposure duration for the child was six years (USEPA, 1989). The exposure frequency was estimated to be 350 days/year (USEPA, 1989). A ground water ingestion rate of 2 L/day was used for adults, while the child was assumed to ingest 1 L/day (USEPA, 1991b). For dermal contact with ground water and inhalation of vapors that may occur while showering, an exposure time of 0.2 hours/day was assumed (USEPA, 1989). The soil ingestion rate of 100 mg soil/day was used for adults and an ingestion rate of 200 mg soil/day was assumed for children (USEPA, 1991). Dermal contact with soil assumed an estimated skin surface area of 5,300 cm²/day for adults and 2000 cm²/day for children. These skin surface areas represent contact with the skin surface area of the head, neck, arms and hands (USEPA, 1997). The inhalation rate for the adult resident was 0.552 m³/hr and 0.417 for children assuming moderate activity over long term exposure (USEPA, 1997).

5.1.2.3 *Trespassers*

Trespassers were assessed for potential exposures to affected on-site soils. A soil ingestion rate of 100 mg/day was assumed. Dermal contact with soil assumed a skin surface area of 3,500 cm²/day (e.g., approximately 25% of the total body surface area) which represents the skin surface area of the hands, arms, and lower legs of an adolescent (USEPA, 1997). The exposure frequency was conservatively set at 12 days/year for possible contact with affected media at this rural, isolated site.

Trespassers were also evaluated for potential exposures to surface water and sediment present in the off-site drainage ditch. A sediment ingestion rate of 25 mg/day, which is ¼ of the default soil ingestion rate, was used. Exposure to surface water in the stream was estimated using the same assumptions and frequency as for soil/sediments.

5.2 **EVALUATION OF ANALYTICAL SAMPLING DATA**

5.2.1 *Summary of Data Collected*

Data evaluated within this SRE consisted of samples collected from on-site consolidated material, soil, and the bedrock aquifer ground water. In addition, surface water and sediment samples were collected from the off-site ditch. The sampling locations and results of analysis for each medium are discussed in Section 4.0.

Data Segregation for Quantitative Risk Evaluation

To appropriately assess risk for the selected receptor populations, the data for each medium were segregated to estimate constituent EPCs that may be contacted by each population. Specifically, soils and perched ground water were grouped according to on-site versus off-site sampling locations and were generally delineated by the property boundary. Further, within the soil data sets, samples collected from borings to a depth of 14 feet were used to predict potential exposures that may occur with surface and subsurface soils should excavation activities occur in the future. Surface soils (0 to 2 feet) data were not significantly different than subsurface soils, thus the same data set was used to estimate risk for all potentially exposed human receptors assessed herein. The data groupings are provided below. The grouped analytical data for each medium are provided in Appendix J.

<i>Medium</i>	<i>Sample Locations</i>
Bedrock ground water	MW-1, MW-2, MW-3
Off-site perched ground water	GB-1, GB-3, GB-4, GB-7, GB-9, GB-11, GB-13, GB-15, MW-9, MW-10, MW-11, MW-12, MW-13, MW-14
On-site perched ground water	SM-1, SM-4, SM-8, SM-9, MW-4, MW-5, MW-6, MW-7, MW-8,
Off-site soil	GB-1, GB-2, GB-3, GB-4, GB-5, GB-6, GB-7, GB-8, GB-10, GB-11, GB-12, GB-13, GB-14, GB-15, GB-17
On-site soil	SM-1, SM-2, SM-3, SM-4, SM-5, SM-6, SM-7, SM-8, SM-9, SM-10, SS-SS, SB-1, SB-2, SB-3, SB-4, SB-5, SB-6, SB-7, SB-8, SB-9, SB-10, SB-11, SB-12, SB-13, MW-13
Surface water	SW-1, SW-2, SW-3, SW-4
Sediment	SED-1, SED-2, SED-3, SED-4

All analytical data reported during the field investigations at this site have been validated using USEPA data validation methodology (see Section 4.6). All data used within this assessment were considered useable for risk assessment purposes. Laboratory validation qualifiers were treated according to USEPA guidance (USEPA, 1989). Non-detection results ("U" qualifiers) were included only if other results for a given constituent in a particular medium/area indicated the constituent was present. In these instances, half the reported sample quantitation limit was used. Estimated results, usually indicated by a "J" qualifier, were included in the data evaluation.

The analytical results for duplicate samples were averaged in the following manner in accordance with USEPA guidance (USEPA, 1989). The resulting value was the arithmetic mean of the detected concentrations if the analyte was detected in both samples or the arithmetic mean of the reported detection limits if both samples were non-detects. If one of the duplicate samples was a positive detect and the other a non-detect, the detected result was used to represent the sample (i.e., the samples were not averaged and the detection limit was not used).

In accordance with current risk assessment guidance (USEPA, 1989; 1992c), the constituent-specific exposure point concentrations used in risk calculations were based on either the 95% upper confidence limit of the mean for each log transformed data set (UCLt95) or the maximum detected concentration; the lower of these two values (designated as the "exposure point concentration" [EPC]) was used in the risk calculations. Use of the maximum concentration to represent the EPC may frequently occur when fewer than 10 samples are within a data set or when there is large variability in the data set (i.e., only a few samples within a data set report elevated detections of a constituent with most samples reported as non-detections).

The following equation was used to calculate the UCLt95 for the site data (USEPA, 1992c):

$$UCLt95 = e^{\left(\bar{x} + \frac{s^2}{2} + \frac{sH}{\sqrt{n-1}} \right)}$$

where:

UCLt95 =	95 % upper confidence limit of the mean of the log transformed data set;
\bar{x} =	mean of the log-transformed data;
s =	standard deviation of the log-transformed data;
H =	H statistic for the 0.95 confidence interval; and
n =	sample size (number of samples analyzed).

The statistical parameters defined above for each constituent data set are provided in Appendix J. The selected medium-specific EPCs for each constituent is provided in Table 5-4.

It is noted that on-site soil EPCs are conservatively high because the data set includes a large number of stabilized material samples from the Consolidation Area, some reporting high concentrations. In particular, the on-site soil EPC for Aroclor 1254 is conservatively high. This is because the data set is highly matrix dependent and includes several samples with elevated quantitative estimates of Aroclor 1254 based on high laboratory detection limits resulting from sample matrix interference during analyses.

Because of the limited number of samples, EPCs for surface water and sediment were based on the maximum reported concentrations. The medium-specific EPCs are provided in the tables discussed in Section 5.4 in which carcinogenic and noncarcinogenic risks have been calculated.

5.2.4 *Comparison of Site Data to Background Concentrations*

Site-specific background concentrations for inorganic constituents in soil were calculated using statistical analyses provided in Gilbert (1987). Background concentrations were derived from three soil horizons (upper horizon - 0.5 to 1.0 feet, lower horizon - 1.5 to 2.0 feet, and both horizons - 0.5 to 2.0 feet). Each data set was assessed to determine distribution by using the Shapiro-Wilks statistic. These analyses are provided in Appendix G. For risk assessment purposes, the calculated background

concentrations representative of both soil horizons were used for comparison to site soils. This comparison is provided in Table 5-5. As shown in Table 5-5, several of the metals detected in the soil were only slightly higher than the background concentrations.

5.2.5

Summary of Constituents Retained for Risk Evaluation

All constituents, except arsenic, that were detected in at least one sample were retained for evaluation in the risk evaluation. Arsenic was eliminated from further evaluation in the risk assessment because the reported soil concentrations were less than the calculated background concentration.

5.3

TOXICITY ASSESSMENT

This section presents toxicity criteria and information that relates constituent exposure (dose) to anticipated health effects (response) for each constituent. Toxicity criteria derived from dose-response data were used in the Risk Characterization section to estimate the carcinogenic and noncarcinogenic risks associated with exposure to these constituents.

Toxicity criteria used in this risk assessment were obtained from USEPA's Integrated Risk Information System (IRIS) on-line database, other appropriate USEPA guidance documents and the scientific literature. Toxicity criteria were obtained from the following sources, listed in descending order of use:

- Integrated Risk Information System (IRIS) (USEPA, 1999),
- Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997), and
- USEPA's National Center for Environmental Assessment (NCEA) as indicated in USEPA Region III (1999).

A summary of the relevant toxicity criteria is presented in Table 5-6. Risk calculation tables discussed in Section 5.4 contain available oral cancer slope factors (CSFs) which were used to evaluate carcinogenic risk. These tables also contain the available oral chronic reference doses (RfDs) that were used to evaluate noncarcinogenic risks. Available inhalation unit risk factors were converted into inhalation slope factors and inhalation reference concentrations were converted into inhalation reference doses in accordance with USEPA guidance (1989). Using the oral absorption efficiencies provided in Table 5-6, oral CSFs and RfDs were adjusted for absorption to allow comparison with calculated dermal doses (USEPA, 1989). Interim toxicity criteria obtained from NCEA are also included in

this table for certain RfDs that were not available in IRIS or HEAST. In addition, CSFs and RfDs that have been withdrawn from IRIS or HEAST by USEPA were included, where available, for those constituents lacking current toxicity criteria.

Chemical-specific permeability constants (PCs) used to estimate dermal exposure are also provided in Table 5-6. Although these values do not represent toxicity criteria, they are included as part of the chemical-specific information cited in Table 5-6.

5.4 RISK CHARACTERIZATION

Potential human health risks attributable to the site constituents are discussed in this section. The risk characterization integrates data developed from the exposure assessment and the toxicity assessment to derive numerical estimates of carcinogenic and noncarcinogenic risks. Risks from the site were assessed for each potential exposure medium (e.g., soil, ground water, surface water, and sediment) under the "reasonable maximum exposure" (RME) conditions described previously. The risk information was used together, with risk management considerations, in evaluating the necessity for removal action.

5.4.1 Carcinogenic Risk

The incremental carcinogenic risk associated with exposure to constituents detected at the site was calculated according to the following equation (USEPA, 1989):

$$\text{Incremental Carcinogenic Risk} = \text{Cancer Slope Factor} \times \text{Dose}$$

where the incremental carcinogenic risk represents the probability of developing cancer over a 70-year lifetime from exposure to the constituents associated with the site. Cancer risk is unitless and is expressed here in scientific notation. For example, a risk of 1×10^{-6} indicates that an individual has one chance in one million of developing cancer as a result of exposure to on-site constituents during a lifetime.

The cancer slope factor represents the carcinogenic potency of a constituent. The dose, or intake, represents the amount of constituent to which a receptor is exposed. When evaluating carcinogenic risks, the dose is the estimated daily intake of each constituent during the specified period of exposure, and averaged over a 70-year lifetime.

Incremental carcinogenic risk was calculated for each constituent having a designated cancer slope factor for all applicable exposure pathways. Risk values for all constituents assessed were summed by exposure pathway to provide total pathway-specific risks.

The USEPA has not identified a single value that represents a significant incremental cancer risk. However, the National Contingency Plan (NCP) sets the acceptable cancer risk range at 1×10^{-4} to 1×10^{-6} (NCP, 1990). In other words, the goal of the NCP is to reduce the cancer risk associated with site constituents in a given medium to within or below a range of one in ten thousand to one in one million.

5.4.2 *Noncarcinogenic Effects*

Potential noncarcinogenic effects were evaluated based on a comparison of constituent-specific chronic exposure doses with corresponding protective doses derived from health criteria. The result of this comparison is expressed as the Hazard Quotient (HQ):

$$\text{Hazard Quotient} = \text{Dose} / \text{Reference Dose}$$

A HQ that exceeds unity (one) suggests a potential of developing an adverse subchronic or chronic toxic effect. However, the uncertainty factors built into the protective dose result in conservative reference dose values. Therefore, the reference dose is likely well below the level at which adverse effects will be seen.

HQs were calculated for each constituent for which reference doses are currently available. The HQs for each constituent were summed to produce a rough estimate of the pathway-specific risk, the Hazard Index (HI). In estimating total noncarcinogenic risk, potential responses were conservatively assumed to be additive for site constituents within a given medium. However, all constituents do not have the same or similar toxic endpoints and responses may not be additive.

5.4.3 *Discussion of Site Risks*

5.4.3.1 *Carcinogenic Effects*

Bedrock Ground Water

As described in Section 5.1, the regional bedrock aquifer may be used as a source of drinking water for residential receptors. Although exposures to site-related constituents are not expected, cancer risks were estimated for both adult and child receptors that use ground water as a residential

water supply. The cancer risk estimates for the child receptor for ingestion and dermal contact while showering are shown in Tables 5-7 and 5-8, respectively. Cancer risk estimates for the adult receptor for ingestion and dermal contact while showering are shown in Table 5-9 and 5-10, respectively. Cancer risk estimates for inhalation of vapors during showering are shown in Table 5-10a for both adult and child residential receptors.

The estimated total cancer risk for the child resident is 6×10^{-7} . The estimated total cancer risk for the adult was estimated to be 1×10^{-6} . It is noted that the cancer risk for the adult was at USEPA's benchmark cancer risk of 1×10^{-6} . Further, only one carcinogenic constituent (bis (2-ethylhexyl) phthalate) was detected in the ground water. For both adult and child receptor populations, the resultant risks were below or within the acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} .

Perched Off-Site and On-Site Ground Water

As described in Section 4.0, perched ground water cannot be used as a potable water supply. Therefore, potential exposures are limited to construction workers who may have contact with perched ground water that may accumulate in excavations or trenches. The estimated cancer risk for construction worker dermal contact and inhalation exposures with perched off-site ground water under such exposure conditions are provided in Tables 5-11 and 5-12. The estimated cancer risk for dermal exposure with off-site perched ground water by the construction worker was 3×10^{-9} . No volatile carcinogenic constituents were detected in the off-site perched ground water, thus no cancer risk were calculated.

Estimated cancer risks for the construction worker dermal contact and inhalation exposures with perched on-site ground water are provided in Tables 5-13 and 5-14. The estimated cancer risk for dermal exposure with on-site perched ground water by the construction worker was 9×10^{-7} . The estimated cancer risk for inhalation exposure by the construction worker was 2×10^{-7} . The resultant cancer risks for the construction worker potentially exposed to off-site and on-site perched ground water were 3×10^{-9} and 1×10^{-6} , respectively. These estimated risks for the construction worker were within the acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} .

Soils

Although exposures to affected soils at the site are unlikely, cancer risks were estimated for potentially exposed populations, including future construction workers, off-site residents and trespassers. Risks were

assessed for incidental ingestion, dermal contact and inhalation of volatile emissions and fugitive dusts. Volatilization factors calculated using procedures outlined in USEPA (1996) for each volatile constituent are presented in Table 5-15.

As previously described, soil data was segregated according to off-site and on-site locations. The estimated risks associated with each of these soil groupings are described below.

Off-Site Soil

Tables 5-16 through 5-18 summarizes the cancer risk estimates for future construction workers who may be exposed to off-site affected soils. For this exposed population, ingestion, dermal contact and inhalation of volatile emissions and fugitive dusts were assessed. The estimated total cancer risk for the future construction workers was 1×10^{-9} , which was well below the USEPA's benchmark of 1×10^{-6} .

Tables 5-19 through 5-24 summarize the potential cancer risk for the adult and child residents. The cumulative carcinogenic risks of 1×10^{-7} were estimated for the adult resident and 1×10^{-7} for the child resident. Both cancer risk estimates were well below USEPA's benchmark of 1×10^{-6} .

On-Site Soils

Tables 5-25 through 5-27 summarizes the cancer risk estimates for future construction workers who may be potentially exposed to on-site soils. For this potentially exposed population, ingestion, dermal contact and inhalation of volatile emissions and fugitive dusts were assessed. The estimated cumulative cancer risk for the future construction workers exposed to on-site soils was 4×10^{-6} , which is within USEPA's acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} .

Tables 5-28 through 5-30 summarize the potential cancer risk for the occasional trespassers who may be exposed to on-site soil. The cumulative carcinogenic risk of 3×10^{-6} estimated for trespassers was within the USEPA's acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} .

Surface Water

Only one constituent, bis-(2-ethylhexyl) phthalate, was detected in surface water samples collected from the off-site ditch. Risks for potential exposures for construction workers who may have limited contact with affected surface water are provided in Table 5-31. The estimated cancer

risk of 1×10^{-9} for future construction workers was below the USEPA's benchmark of 1×10^{-6} .

Risks associated with potential exposure to this constituent were also assessed for the occasional trespasser. Tables 5-32 and 5-33 summarize the estimated carcinogenic risk for trespassers. As shown in the tables, the total cancer risk of 1×10^{-9} for trespassers from cumulative (e.g., ingestion and dermal contact) exposure to carcinogens in the surface water was much lower than the USEPA's benchmark of 1×10^{-6} .

Sediment

Sediment samples collected from the same locations as surface water samples were used to evaluate potential exposures by future construction workers and occasional trespassers. Table 5-34 summarizes the risk evaluations for future construction workers at the site. The potential cancer risk of 1×10^{-8} for future construction workers was below the USEPA's benchmark of 1×10^{-6} .

Tables 5-35 and 5-36 summarize the risk evaluations for trespassers. As shown in the tables, the total cancer risk of 4×10^{-8} for trespassers from cumulative (e.g., ingestion and dermal contact) exposure to carcinogens in the sediment was much lower than the USEPA's benchmark of 1×10^{-6} .

5.4.3.2

Noncarcinogenic Effects

Bedrock Ground Water

Consistent with the evaluation of potential estimates of cancer risk, noncancer risks were estimated for both adult and child receptors who may have contact with affected ground water via ingestion and dermal contact while showering. The noncarcinogenic risk estimates for each population for each route of exposure are provided in Tables 5-7 and 5-8 for the child receptor and Tables 5-9 and 5-10 for the adult. Estimated noncarcinogenic risks for adult and child receptor exposures to vapors while showering are provided in Table 5-10a. The hazard index for the child receptor was estimated to be 0.9. The hazard index for the adult was estimated to be 0.4. For both adult and child receptor populations, the resultant noncancer risks were well below the acceptable hazard index of 1.0.

Perched Off-Site and On-Site Ground Water

As described in Section 3.3, perched ground water cannot be used as a potable water supply. Therefore, potential exposures are limited to

construction workers who may have contact with perched ground water that may accumulate in excavations or trenches. The estimated noncarcinogenic risks for construction worker dermal contact and inhalation exposures with perched off-site ground water are provided in Tables 5-11 and 5-12. The estimated noncarcinogenic risk for dermal exposure with off-site perched ground water by the construction worker was 0.01. The estimated noncarcinogenic risk for inhalation exposure of volatile constituents present in the perched off-site ground water by the construction worker was 0.0004. The resultant hazard index (HI = 0.01) for potential construction worker exposures to off-site perched ground water were well below the acceptable hazard index of 1.0.

Estimated noncarcinogenic risks for the construction worker dermal contact and inhalation exposures with perched on-site ground water are provided in Tables 5-13 and 5-14. The estimated noncarcinogenic risk for dermal exposure with on-site perched ground water by the construction worker was 1.2. The estimated noncarcinogenic risk for inhalation exposure of volatile constituents by the construction worker was 0.6. The noncarcinogenic risk estimated for potential exposure to on-site perched ground water (HI= 1.8) was slightly above the acceptable HI of 1.0.

Soil

Consistent with the estimates of cancer risk for exposures to soil, noncancer risks were estimated for potentially exposed populations: trespassers and future construction workers. Noncarcinogenic risks were assessed for incidental ingestion, dermal contact and inhalation of volatile emissions and fugitive dusts. Volatilization factors calculated using procedures outlined in USEPA (1996) for each volatile constituent are presented in Table 5-15.

Off-Site Soil

Tables 5-16 through 5-18 summarize the noncarcinogenic risk estimates for future construction workers potentially exposed to off-site soils. For this exposed population, ingestion, dermal contact and inhalation of volatile emissions and fugitive dusts were assessed. The cumulative noncancer risk of 0.06 estimated for future construction workers was below the acceptable HI of 1.0.

Tables 5-19 through 5-24 summarize the noncarcinogenic risk for the adult and child residents. For this exposed population, ingestion, dermal contact and inhalation of volatile emissions and fugitive dusts were assessed. The estimated HI of 0.2 for the adult resident and 0.8 for the child resident were well below the acceptable hazard index of 1.0.

On-Site Soils

Tables 5-25 through 5-27 summarize the noncarcinogenic risk estimates for future construction workers potentially exposed to on-site soils. For this potentially exposed population, ingestion, dermal contact and inhalation of volatile emissions and fugitive dusts were assessed. The estimated HI of 5 for future construction workers was above the acceptable hazard index of 1.0. This potential risk was driven by the conservatively high soil EPC for Aroclor 1254. The soil data set for Aroclor 1254 was highly matrix dependent and accordingly included several samples with elevated quantitative estimates of the compound based on high laboratory detection limits resulting from sample matrix interference during analyses.

Tables 5-28 through 5-30 summarize the potential noncarcinogenic risks for the occasional trespassers. The HI of 0.6 for trespassers was below the acceptable hazard index of 1.0.

Surface Water

Only one constituent, bis-(2-ethylhexyl) phthalate, was detected in surface water samples collected from the off-site ditch. Risk for potential exposures for construction workers who may have limited contact with affected surface water are provided in Table 5-31. The HI of 0.0003 for future construction workers was below the acceptable benchmark of 1.0.

Tables 5-32 and 5-33 summarize the estimated noncarcinogenic risk for trespassers. The cumulative noncancer risk of 7×10^{-5} was estimated for the occasional trespassers who may be exposed to surface water. This HI was much lower than the acceptable benchmark of 1.0.

Sediment

The future construction worker and the occasional trespassers were evaluated for potential exposures to sediments. Table 5-34, which presents future construction workers' exposure, indicates an estimated noncancer risk of 0.004. This HI was well below USEPA's acceptable benchmark of 1.0.

Tables 5-35 and 5-36 summarize the risk evaluations for the occasional trespassers. As shown in the tables, a HI of 0.002 was estimated for trespasser exposures. This HI was well below USEPA's acceptable benchmark of 1.0.

5.4.3.3

Lead Exposures

Lead was detected in soil ranging from 4.1 to 811 mg/kg. The calculated EPC of 33.3 mg/kg for off-site soil is below the residential lead screening level of 400 mg/kg (OSWER 9355.4-12, July 14, 1994). Only one sample, GLSS SM-8, which was collected from the waste material, reported a lead concentration above 400 mg/kg (811 mg/kg). All remaining samples reported lead concentrations well below the screening level of 400 mg/kg.

Total lead was detected in bedrock ground water ranging from 0.004 to 0.014 mg/L. Total lead was also reported in perched off-site ground water ranging from 0.0095 to 0.36 mg/l and in on-site perched ground water ranging from 0.003 to 3.5 mg/l. The calculated EPC was 0.19 mg/l for perched off-site ground water and 3.35 mg/l for on-site perched ground water. The lead concentrations reported in the bedrock ground water were below the drinking water standard action level of 0.015 mg/l (which applies lead levels reported at the tap). Although the lead levels reported in the perched ground water were higher than the lead action level, it is important to note that the perched ground water cannot be used as a potable drinking water supply (see Section 3.3). Further, the reported levels represent the total concentration of lead rather than the dissolved phase lead that may be ingested should a drinking water well were installed.

5.5

UNCERTAINTY ANALYSIS

The goal of the risk assessment was to provide reasonable maximum risk estimates to guide decision-making using exposure scenarios required by USEPA. By using standardized methodology guidelines, in particular, *Risk Assessment Guidance for Superfund, Part A* (USEPA 1989) and standardized default exposure factors provided in USEPA (1991a), this risk assessment provides a conservative basis for determining whether removal actions need to be considered.

USEPA (1991a) states that, "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 1×10^{-4} , and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts." Moreover, USEPA guidance (USEPA, 1989) acknowledges that uncertainty in a risk assessment can cause differences in the numerical results of more than an order of magnitude. Therefore, it is important to document and discuss the types of uncertainties that may affect the risk estimates calculated in the previous section.

Risk is broadly a function of exposure and toxicity. Therefore, uncertainties in characterizing either of these can lead to inaccuracy in risk estimates. Specific sources of uncertainty can be divided into two groups: methodological and site-specific. These types of uncertainties are described in the following subsections. Their effect on final risk estimates is discussed where possible.

5.5.1 *General Methodological and Site-Specific Uncertainties*

5.5.1.1 *Site Characterization*

It is nearly impossible to completely characterize heterogeneous environmental media from a statistical standpoint. Soil constituent concentrations may vary by orders of magnitude over intervals of an inch or less; air constituent concentrations vary greatly over space and time. In some cases, only a few samples are available to evaluate a particular medium or source area. Risk estimates based on a limited sample database may not be representative of actual contamination over the entire site. However, for the Greiner's Lagoon Site, numerous samples were collected from the Consolidation Area; and therefore, the database is considered a very conservative representation of site wide impacts due to Site activities.

The data reported for this assessment have met the analytical requirements and are of sufficient quality and are considered useable for purposes of site characterization and risk assessment. The data quality is detailed in Section 4.6. It is noted that many samples were diluted because of the suspected chromatographic interference present in the samples. The initial dilutions were required to prevent saturation of the instrument and to allow adequate chromatographic resolution and quantitation of the constituents with the linear calibration range of the instrument. This resulted in higher quantitation limits for constituents that were not reported in these samples.

5.5.1.2 *Toxicological Information*

Toxicity data used for human health risk assessment can be limited. Much of the data used to generate health criteria are derived from animal studies. Uncertainties result given that:

- Both endpoints of toxicity (effect or target organ) and the doses at which effects are observed are extrapolated from animals to humans;
- Results of short-term exposure studies are often used to predict the effects of long-term exposures;

- Results of studies using high doses are used to predict effects from exposures to low doses usually expected at hazardous waste sites; and
- Effects exhibited by homogeneous populations of animals (or humans) are used to predict effects in heterogeneous populations with variable sensitivities (e.g., the young, elderly or infirm).

In addition, thorough toxicity data are not available for all constituents detected at many sites.

USEPA and other regulatory agencies attempt to account for these sources of uncertainty by including uncertainty factors in the determination of health criteria such as RfDs. In addition, the level of confidence in RfDs for noncarcinogenic effects and the weight of evidence for carcinogenic effects are specified for each constituent.

USEPA published draft revisions to their cancer risk guidelines on 23 April 1996 in the Federal Register (61FR17960-18011). These revised guidelines provide new risk assessment tools for application in setting risk-based remedial goals. Departures from the Linearized Multistage Model (LMS) result in the development of risk-based cleanup goals which often are orders of magnitude higher than those established using former USEPA default methodology.

As indicated below, USEPA's recently revised carcinogen assessment guidelines also encourage alternative dose-response models in assessing risk from nongenotoxic carcinogens.

"Curve-fitting models are used that are appropriate to the kind of response data in the observed range. Any of several models can be used; e.g., the models developed for benchmark dose estimation for noncancer endpoints may be applied. The mode of action may theoretically have a threshold, e.g., the carcinogenicity may be a secondary effect of toxicity or of an induced physiological change that is itself a threshold phenomenon" (USEPA, 1996b).

In particular, utilization of the LMS model for assessing risks from, and establishing cleanup goals for, many chemicals that have tested positive only for liver tumors in laboratory rodents is inappropriate and not cost effective.

Over the past two decades many organochloride chemicals were indicated as USEPA Class B2 (probable human) carcinogens when tested by the U.S. National Toxicology Program (NTP) protocol. These tests employed feeding laboratory rodents test substances in maximally tolerated doses

for a lifetime, and resulted in the formation of hepatocellular adenomas, some of which progressed to hepatocellular carcinomas. This response is now known to be due to liver tissue injury and enzyme induction in these rodent strains, and not a true measure of carcinogenicity at environmentally relevant doses in potential human receptors. The same organochlorides are not genotoxic to DNA or chromosomes in short-term test systems and are active in carcinogenic promotion rather than initiation. The list of organochloride chemicals which fall into this USEPA Class B2 carcinogen category includes some of the VOCs found at the Site.

5.5.1.3 *Exposure Assumptions*

Evaluating exposure to environmental constituents requires a number of different inputs and assumptions. These include the types of exposed populations, including their ages and health conditions; average lifespans; activity patterns such as time spent indoors versus outdoors; time spent at different locations; time spent working or residing in the area of the site; contact rates with contaminated media; skin surface area for dermal contact; and absorption rates via the skin and digestive tract. There are significant uncertainties regarding the extent to which a constituent is absorbed from soil through the skin.

Current USEPA guidance for conducting risk assessments recommends values to be used for many of these parameters. This serves to reduce unwarranted variability in exposure assumptions used to perform baseline risk assessments across different sites.

Because values specified in guidance documents are often conservative, upper-bound figures, they would rarely lead to underestimating risks. Site-specific exposure parameters should be used over standard default exposure parameters when they are known to prevent masking of site-specific variations.

Risk assessments also estimate current and future exposure scenarios based on constituent concentrations detected at the site during the site investigation. In general, no attenuation or degradation of constituents over space or time is assumed. This also results in a conservative estimate of risk.

5.5.1.4 *Risk Characterization*

Constituent-specific risks are generally assumed to be additive. This oversimplifies the fact that some constituents are thought to act synergistically ($1 + 1 > 2$) while others act antagonistically ($1 + 1 < 2$). The overall effect of these mechanisms on multi-constituent, multi-media risk

estimates is difficult to determine but the effects are usually assumed to balance or to result in an overestimate of potential risk.

5.6

CONCLUSIONS

Based on the findings of this SRE, estimated carcinogenic risks for each human receptor population were below USEPA's benchmark of 1×10^{-6} for most pathways of exposure. Potential exposure with some affected media resulted in estimated risks that were marginally above USEPA's benchmark, but were well within USEPA's acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} . The noncarcinogenic hazard indices estimated for off-site residents, adolescent trespassers and construction workers (workers who may be exposed to off-site media) were below USEPA's benchmark of 1.0. Potential exposures to on-site soil and on-site shallow ground water by the construction worker resulted in noncarcinogenic hazard indices above USEPA's benchmark of 1.0. The resultant risk estimated are summarized in Table 5-37 and described below.

The purpose of this SRE was to evaluate potential risks posed by residual site constituents. It should be noted that human access to the area surrounding the Site is limited and that frequent contact with constituents that may be present at the Site will not occur on a daily basis. Further, the opportunity for exposure to affected soil is significantly reduced because the inactive Site, consisting of four former lagoons, has been dewatered, partially stabilized, filled and covered with a layer of clean soil. To address USEPA requirements, three conservative human exposure scenarios for the current and future use of the site were evaluated in this assessment. These human receptor groups consisted of future construction workers, local residents and occasional trespassers. Each of these hypothetical populations was evaluated for potential exposures to affected media at the site. The complete pathways for each population are shown in Table 5-1.

Based on a conservative estimation of risk for each receptor population, the resultant carcinogenic and noncarcinogenic risks were provided in Section 5.4. Each evaluated medium and potentially exposed receptor population is described briefly below.

Bedrock Ground Water

As described in Section 5.1.1, bedrock ground water may be used by local residents for a source of drinking water. For both adult and child receptor populations, estimated carcinogenic risks were 1×10^{-6} and 6×10^{-7} , respectively. These risks well below or within the acceptable risk range of

1×10^{-4} to 1×10^{-6} . Likewise, noncarcinogenic risks were estimated at 0.4 for adults and 0.9 for children. Those noncarcinogenic risks were well below 1.0.

Perched Off-Site and On-Site Ground Water

As previously described, perched ground water cannot be used as a potable water supply. Therefore, potential exposures are limited to construction workers who may have contact with perched ground water that may accumulate in excavations or trenches. The estimated cancer risk for dermal exposure with off-site perched ground water by the construction worker was 3×10^{-9} . No volatile carcinogenic constituents were detected in the off-site perched ground water, thus no cancer risk were calculated. The estimated noncarcinogenic risk for dermal exposure with off-site perched ground water by the construction worker was 0.01. The estimated noncarcinogenic risk for inhalation exposure of volatile constituents present in the perched off-site ground water by the construction worker was 0.0004.

The estimated cancer risk for dermal exposure with on-site perched ground water by the construction worker was 9×10^{-7} . The estimated cancer risk for inhalation exposure by the construction worker was 2×10^{-7} . The estimated noncarcinogenic risk for dermal exposure with on-site perched ground water by the construction worker was 1.2. The estimated noncarcinogenic risk for inhalation exposure of volatile constituents by the construction worker was 0.6.

The resultant cancer risks for the construction worker potentially exposed to off-site and on-site perched ground water were 3×10^{-9} and 1×10^{-6} , respectively. These estimated risks for the construction worker are below or within the acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} . The resultant hazard index for potential exposures to off-site perched ground water were well below the acceptable hazard index of 1.0. The noncarcinogenic risk estimated for potential exposure to on-site perched ground water (HI= 1.8) was slightly above the acceptable HI of 1.0.

Soils

Off-Site Soils. Potential exposures to off-site soils were evaluated for the on-site construction worker and local residents. The estimated cumulative cancer risk of 1×10^{-9} for future construction workers was well below USEPA's cancer risk benchmark of 1×10^{-6} . The cumulative carcinogenic risks of 1×10^{-7} for adult resident and 1×10^{-7} for the child resident are well below USEPA's cancer risk benchmark of 1×10^{-6} . The cumulative noncancer risk of 0.06 for future construction workers was below the

acceptable HI of 1.0. Likewise, the HIs of 0.2 for adult resident and 0.8 for the child resident were well below the acceptable HI of 1.0.

On-Site Soils. Potential exposures to on-site soils were evaluated for the on-site construction worker and the occasional trespasser. The estimated cumulative cancer risk of 4×10^{-6} for future construction workers was within the acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} . The potential estimated carcinogenic risk of 3×10^{-6} for trespassers was within the acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} . The estimated hazard index of 5 for future construction workers was above the acceptable hazard index of 1.0. The hazard index of 0.6 for trespassers was below the acceptable hazard index of 1.0.

As previously noted, the potential risks for construction worker exposures were driven by the high soil EPC for Aroclor 1254. The soil data set for Aroclor 1254 was highly matrix dependent and accordingly included several samples with elevated quantitative estimates of the compound based on high laboratory detection limits resulting from sample matrix interferences during analyses.

Surface Water

Potential exposures to surface water in the off-site ditch were assessed for the trespasser and the construction worker. The estimated cancer risks for both the trespasser and construction worker were 1×10^{-9} .

Noncarcinogenic risks were estimated at 0.0003 for the trespasser and 7×10^{-5} for the construction worker. Thus, there were no significant carcinogenic or noncarcinogenic risks estimated for these receptor populations.

Sediment

Potential exposures to sediment in the off-site ditch were also assessed for the trespasser and the construction worker. The estimated cancer risks for both the trespasser and construction worker were 4×10^{-8} and 1×10^{-8} , respectively. Noncarcinogenic risks were estimated at 0.002 for the trespasser and 0.004 for the construction worker. Similar to surface water exposures, there were no significant carcinogenic or noncarcinogenic risks estimated for these receptor populations.

An ecological risk assessment is a qualitative and/or quantitative appraisal of the actual or potential effects of a site on plant and animal communities. Ecological risk assessment can range from simple to complex depending upon the site in question.

Based on U. S. EPA Region V guidance (EPA 1994), there are three tiers to the ecological risk assessment process that require successively more detailed and quantitative data collection, analysis, and evaluation to determine the degree of risk. The three tiers are referred to as the screening ecological risk assessment (SERA), preliminary ecological risk assessment (PERA), and detailed ecological risk assessment (DERA). The purpose of this screening and preliminary ecological risk assessment is to estimate potential risks to ecological receptors from Greiner's Lagoon Site.

An ecological reconnaissance of the entire 9.76 acre Greiner's Lagoon Site and its surrounding environs was conducted by an ERM ecologist on March 27, 1997. The purpose of the reconnaissance was to identify major habitat cover types, identify potential ecological receptors and characterize potential exposure pathways. The reconnaissance was enhanced through the review of existing data, maps, aerial photographs, pertinent literature, and information provided by federal and Ohio natural resource agencies.

In addition to the Site reconnaissance, data evaluated within this SERA consisted of samples collected from on-site consolidated material and soil, as well as surface water and sediment samples collected from the off-site ditch. All analytical data reported during the field investigations at this site have been validated using USEPA data validation methodology. All data used within this assessment were considered useable for risk assessment purposes.

6.1

PROBLEM FORMULATION

Problem formulation establishes the goals and focus of the PERA. Measurement endpoints are selected based upon sensitivity, response time, diagnostic ability and practicality. Primary tasks of problem formulation consist of:

- habitat/species characterization
- identification of stressors

The results of each of these tasks are described below.

6.1.1 *Habitat /Species Characterization*

Biological features of the Site and surrounding area were identified during the reconnaissance and used in the exposure estimate to identify potential ecological receptors and to characterize potential exposure pathways.

6.1.1.1 *Site Description*

The 9.76 acre Greiner's Lagoon Site is located south of Fremont, Ohio, on County Road 181 approximately one-half mile west of Tiffin Road in Ballville Township, Sandusky County, Ohio. The Site originally consisted of four lagoons that were used to store waste collected from nearby industries. The collection and storage began in 1954. The addition of waste to the lagoons ceased in 1970 and a dike system was constructed around the four lagoons in 1973. In the 1980's, the lagoons were dewatered, partially stabilized, filled, and covered with a layer of clean soil. The site is surrounded by active agricultural land, primarily of row crops.

6.1.1.2 *Habitat Covertypes*

The habitat covertypes that occur on the 9.76 acre Site are shown in Figure 6-1 and the species present within these habitats are listed in Table 6-1. A general description of these habitats is provided in the following paragraphs of this section of the report.

A clean soil cover was installed by USEPA in 1987 over the stabilized material and provides continuous coverage over the impacted material. It is bare of vegetation except for a few patchy areas of goldenrod, aster, and grasses. The northern section of the stabilized material is elevated approximately six feet above grade and has some areas of erosion at its perimeter. The southern section of this area is only slightly above grade with surface water flowing predominately to the west. There were small areas of oil seepage at the time of the Site reconnaissance. These seeps were subsequently repaired. Surface water from the Site flows into an underground pipe which drains into a large drainage channel that empties directly into Indian Creek. Indian Creek is a channelized swale that drains mainly agricultural lands. It may be considered a first or second order stream.

Brush and small trees (sapling/shrub) extend south from the area of stabilized material to a gas line easement. The dominant species in this covertype include goldenrod, aster, teasel, evening primrose, garlic

mustard, burdock, stiff-haired sunflower, cottonwood saplings, black locust, and dogwood. Stinging nettle, cocklebur, and foxtail grass were also present around the edges of this coverytype. A small wet pocket of black willow trees is located within the area of brush and small trees.

Wooded Areas A and B occur at the extreme southern end and west side of the site respectively. These were mixed deciduous woods and are located in somewhat poorly drained soils of the Dixboro-Kibbie complex (SCS 1977). Another small wet area occurs immediately east of Wooded Area A (not mapped on Figure 6-1). This narrow area contained various sedges in standing water. There were numerous areas of ponded water in the woodlands at the time of the field reconnaissance. It should be noted however that the reconnaissance was conducted in the early spring following a relatively wet period.

The dominant tree species present in Wooded Areas A and B were red oak, white oak, swamp white oak, chestnut oak, sycamore, red maple, shag-bark hickory, butternut, hackberry, and beech. Ironwood and dogwood comprised the shrub layer. In Wooded Area B multiflora rose and blackberry were also present as dominant understory plants. Due to the thick cover of leaf litter and early spring season when the site reconnaissance was conducted, no herb layer was evident or observed. A small Marsh Area (approximately 8,100 sq. ft. or 0.2 acres) exists between the capped stabilized material and Wooded Area B. Surface water runoff from the stabilized material to the Marsh Area was evident.

A narrow ditch runs along the east side of the site and contains a small area of *Phragmites* near the northern end. Some algae occurs in the wider areas of the ditch.

A formal wetland delineation was not conducted as part of the Site reconnaissance. However, the wetland areas identified during the Site reconnaissance may be considered jurisdictional wetlands. It should be noted that wetland delineation methodology as developed by the U.S. Army Corps of Engineers (USACE, 1987) require an analysis of three factors: soils, hydrology and vegetation. Soils and hydrology were not evaluated during the Site reconnaissance.

Wetland areas at the Site would include two distinct locations on and/or adjacent to the Site: the small Marsh Area between the capped stabilized material and Wooded Area B, and the wet pocket containing willows within the brush and small tree area just south of the stabilized material. Small pockets within the woodland areas may also be isolated wetlands. These pockets were observed to be associated with small depressional areas within the woodlands and appear to exist due to poorly drained

soils. Based on Site borings and monitoring well installations, there appears to be no apparent connection between the shallow saturated zone and potential wetland habitats on the Site.

The total potential wetland area on the west side of the Site receiving surface water runoff from the Consolidation Area is estimated to be less than one acre. The drainage ditch on the east side of the Consolidation Area which also receives surface water runoff is not likely to be classified as a jurisdictional wetland by the Army Corps of Engineers. Thus, these areas would not be subject to regulation under the Army Corps of Engineers or the Ohio EPA Division of Surface Water Quality (Personal Communication, Ohio EPA Division of Surface Water Quality, 1999).

6.1.1.3 *Sensitive Habitats*

Several potential wetland areas occur on, or directly adjacent to the Greiner's Lagoon Site. The small wet pocket of willows is located south of the fenced area. However, this area should be unaffected by surface water from the former lagoons because of the direction of flow, which is generally toward the north. The mixed deciduous Wooded Area A also appeared to contain wet pockets, but surface water flow was northward, toward the former lagoons. Wooded Area B was also contained wet pockets within the mixed deciduous woods, and may receive surface water flow from the former lagoon area. However, between Wooded Area B and the former lagoons (mapped on Figure 6-1 as "Marsh Area") is an area of sediment buildup due to erosion and sedimentation from the former lagoon area. Because sediment appears to be depositing in this isolated marsh, it does not appear likely that runoff is reaching Wooded Area B. This is confirmed by the analytical data, which are discussed in Section 6.2.1.

Indian Creek flows northwest from the site approximately 5 miles to the Sandusky River which has been designated as a state scenic river. Active agricultural land surrounds Indian Creek with no buffer zone so there is no vegetative cover over the creek. The creek has also been channelized through the fields so there are no riffles, bends or pools. There is no vegetation, organic debris or other cover in the stream.

6.1.1.4 *Species of Special Concern*

The following agencies were contacted for information on rare, threatened or endangered species on, or in the vicinity of, the 9.76 area Greiner's Lagoon Site: Ohio Department of Natural Resources (ODNR) Division of Wildlife, ODNR Division of Natural Areas and Preserves-Heritage Data Services, Ohio Historic Preservation Division-Ohio Historical Society,

United States Department of the Interior Fish and Wildlife Service-Ohio Field Office. Copies of the letters sent to these agencies and their responses are presented in Appendix L.

According to the ODNR Natural Heritage Program database, there is one species of fish of special interest known to occur in the vicinity of the project site (see Appendix L). The river redhorse (*Moxostoma carinatum*) has been collected both upstream and downstream of the confluence of the drainage channel to Indian Creek (which drains the project site) with the Sandusky River. However, the largest numbers of specimens were collected more than 5 miles upstream of the Site and would therefore be unaffected by the Site. Information provided by the ODNR, Division of Wildlife also does not indicate that impacts to the river redhorse were observed downstream of the Site.

The U. S. Fish and Wildlife Service (USFWS) state that 4 species of plants or animals of concern are found in Sandusky County, Ohio (See Appendix L). However, due to the project size and location, none of these species would be affected by the Site.

Other than the river redhorse in the Sandusky River, no agency reported any notable species of special concern, state parks, forests, wildlife or historic areas in the project vicinity. While the vegetated portion of the Site may serve as a stopover for passerine birds (songbirds), agency letters did not indicate that the Site is along a migratory pathway. In fact, aerial photographs reveal that the woodlands present on the Site are small and isolated within a landscape of agricultural fields. There are no open water bodies to attract migratory waterfowl or piscivorous bird species. A list of the potential receptor species that may occur on the site is given in Table 6-2. These species consist mainly of small to large mammals and passerine birds.

The Ohio Historical Society did informally concur that no archeological sites or historic structures had been recorded within the boundaries of the project area. However, OHS did request that further information be provided on the details of the remediation project before they formally concur that impacts would not occur to properties listed or eligible for the National Register of Historic Places. This information will be provided to that office once the response action plans are finalized and approved.

6.1.2

Identification of Stressors

Two types of stressors are typically evaluated as part of a PERA, chemical and physical stressors. Chemical stressors include a variety of contaminants that may have been released to the environment and

potentially pose a threat to ecological habitats or wildlife. Physical stressors include habitat alteration or destruction typically associated with the implementation of corrective activities or background conditions.

This assessment focused on potential chemical stressors which were identified based on previously collected soil samples taken at various locations throughout the Site (Figure 6-1). Analytical data for on-site soil (Table 6-3) and off-site soil (Table 6-4) are evaluated separately. A preliminary list of constituents of potential concern was selected based on the measured chemical concentrations from the on-site soil and off-site borings compared to USEPA Region V recommended screening levels (Beyer, 1990). The results of the screening analyses are presented in Table 6-5 and 6-5a, for on-site soil and off-site soil, respectively. Although typically only surface soils (0-2') are screened for potential ecological effects, soils sampled from 0-1', 2-4', 3-5' and 4-6' depth intervals at the Site were examined for potential effects to ecological receptors.

Surface water and sediment samples were collected from the off-site drainage ditch which receives surface water runoff from the Site via an underground drainage pipe. A preliminary list of constituents of potential concern in surface water was selected based on the measured chemical concentrations compared to Oak Ridge National Laboratory (ORNL) lowest chronic values (ORNL, 1996). A preliminary list of constituents of potential concern in sediment was selected based on the measured chemical concentrations compared to ORNL lowest chronic values for organic compounds and National Oceanic and Atmospheric Administration (NOAA) Effect Range-Low concentrations (ER-Ls) for inorganic compounds (ORNL, 1997). The analytical data and screening analysis of surface water and sediment is presented in Table 6-7.

6.1.3

Assessment Endpoints

Assessment endpoints are explicit expression of the unique or critical ecosystem characteristics or features that are to be protected. Because assessment endpoints often cannot be measured directly, measurement endpoints are developed that can be related, either qualitatively or quantitatively, to the selected assessment endpoint(s).

Assessment endpoints are based on the characteristics of the ecosystem potentially at risk and the exposure pathways within that ecosystem. Exposure pathways originate from an impacted medium (surface soil, sediment or surface water) and end at a potential receptor where adverse effects may occur.

The assessment endpoint for Greiner's Lagoon Site is the maintenance of aquatic and terrestrial ecosystems characterized by the sustained populations of animals and vegetative communities that are not impacted by anthropogenic chemicals introduced by Site activities.

6.1.4 *Measurement Endpoints*

Measurement endpoints are biological or ecological variables that can be measured or observed and are related to the valued characteristic of the ecosystem as described by the selected assessment endpoints. In this assessment it is assumed that healthy, unimpacted ecosystems are characterized by chemical parameters in various media which are less than agency screening criteria and guidelines. Therefore, the measurement endpoints for this PERA are the chemical parameters measured in soils, sediments and surface water and their comparison to the ecological effects screening values mentioned above. This comparison will be made by dividing the Site-specific concentration in a given medium by the constituent specific screening level. The resulting value is termed an environmental effects quotient (EEQ). EEQs greater than one (1) will be considered to indicate a potential ecological risk.

6.2 *ANALYSIS*

6.2.1 *Compounds of Potential Ecological Concern*

Compounds at the Site

A total of 29 constituents were detected in soil, surface water, or sediments at the site. Each of the constituents was compared to a screening level and an EEQ was calculated (maximum constituent concentration detected divided by the screening value). Constituents of potential concern were identified as those with an EEQ greater than one and are listed in Tables 6-5 and 6-5a for soil and 6-7 for sediment and surface water. Identified constituents of potential concern are further discussed below.

On-site soil samples revealed 20 constituents of potential concern with EEQs greater than one (rounding to one significant figure). A summary of the constituents of potential concern with EEQs greater than one is presented in Table 6-6. Acetone, butyl benzyl phthalate, di-n-butyl phthalate and isophorone were also retained as constituents of potential concern since no screening levels were available. Benzene, ethylbenzene, toluene, trichloroethene, xylenes (total), 1,2-dichlorobenzene, 1,4-dichlorobenzene, bis(2-ethylhexyl)phthalate, 2-methylnaphthalene,

naphthalene, phenol, 1,2,4-trichlorobenzene, cadmium, lead, zinc, and Aroclor 1254 were the constituents of potential concern with EEQs greater than one in on-site soils.

As shown in Table 6-5a, no constituents of potential concern were identified for off-site soil since all detected concentrations were below screening levels.

As shown on Table 6-7, bis(2-ethylhexyl)phthalate, arsenic, chromium, copper, lead, nickel and zinc were detected in sediment samples but none of these constituents had EEQs greater than one. Acetone was retained as constituents of potential concern in sediment since it had a calculated EEQ of 8.5. Bis(2-ethylhexyl)phthalate and lead were detected slightly above screening levels in surface water and thus were retained as constituents of potential concern.

6.2.1.1

Fate, Transport, and Ecotoxicity

Volatile Organic Compounds

Acetone

No screening level data could be located for acetone so it has been retained as a COPC. The two significant transport properties for acetone in soil are volatilization and leaching. The volatilization rate is higher from drier soils and acetone is weakly sorbed to soil. Since acetone is completely miscible with water, partitioning of acetone to sediments and suspended solids would not be expected (ATSDR, 1997). Volatilization is the most important fate process for acetone in surface waters. The log of the octanol water coefficient (K_{ow}) of acetone (-0.24) suggests that bioconcentration should not be significant in aquatic organisms. Biodegradation of acetone in soils should be significant with acclimated microorganisms as long as the initial concentration of acetone is below toxic levels (< 500 mg/l) (ATSDR, 1997).

Benzene

Benzene released to soil surfaces partitions to the atmosphere through volatilization, to surface water through runoff, and to ground water as a result of leaching. With a partitioning coefficient (K_{oc}) of 60-83 benzene is highly mobile in soils (ATSDR, 1995a). Other parameters that influence leaching potential include soil type, amount of rainfall, the depth to ground water, and the extent of degradation. Benzene has shown a tendency to adsorb to aquifer solids with adsorption increasing as organic matter content increases. The major fate process for benzene in surface

waters is volatilization. Benzene has a relatively low log K_{ow} of 2.14 and is not expected to significantly bioconcentrate in aquatic organisms (ATSDR, 1995a). Some plants may uptake benzene to a minor degree from soils but air-to-leaf transfer is considered to be the major pathway of vegetative contamination. Benzene is biodegraded in soil under aerobic conditions by a number of microbes but this is not normally a major fate process (ATSDR, 1995a).

Ethylbenzene

Like benzene, volatilization from soils and surface water, and subsurface infiltration are the major fate processes for ethylbenzene (log K_{oc} of 240). Sorption to organic soils will occur to a small extent but spills of ethylbenzene may enhance the mobility of other organic chemicals which do strongly adsorb to soil. With a log K_{ow} of 3.34, ethylbenzene would not significantly bioconcentrate in aquatic organisms (ATSDR, 1990).

Toluene

The majority of toluene released to the environment partitions to air. Under typical conditions more than 90% of toluene in the upper soil layer (< 1m) volatilizes to air within 24 hours. Toluene present in deeper soil (> 1m) will be much less likely to volatilize but may undergo biodegradation (ATSDR, 1992a). The volatilization of toluene from surface waters is also fairly rapid but depends on whether the water is static (half-life 1-16 days) or turbulent (half-life 5-6 hours). The log K_{oc} of 2.5 for toluene indicates that it will be moderately retarded by adsorption to soils rich in organic matter but will readily leach from soils low in organic content. Toluene has a moderate tendency to bioconcentrate in the fatty tissues of aquatic organisms. Metabolism of toluene limits its tendency to biomagnify in the food chain except in species such as eels, crabs and herring which have a low rate of toluene metabolism (ATSDR, 1992a).

Trichloroethene

The majority of trichloroethene present on soil surfaces will volatilize to the atmosphere or leach into the subsurface. The calculated K_{oc} values (log K_{oc} 2.03-2.66) are indicative of medium to high mobility in soils. Biodegradation is favored only under limited conditions. When soil samples containing subsurface bacteria were incubated with trichloroethene for 16 weeks at 20°C, no detectable degradation occurred (ATSDR, 1995b). There is evidence that trichloroethene may inhibit total soil biomass and fungi, possibly resulting in the inhibition of microbial transformation processes. Trichloroethene would volatilize rapidly from surface water and would not be expected to significantly bioconcentrate in

aquatic organisms. Some studies have indicated a slight tendency for trichloroethene to bioconcentrate in terrestrial plants with bioconcentration factors (BCFs) of 4.4 to 63.9 (ATSDR, 1995b).

Xylene

The major environmental transport processes for xylene are volatilization from soils or surface water to the atmosphere as well as fugitive dust emissions and dry deposition. Biodegradation is a primary fate process for xylene with toluic acid and methyl catechol as the principal products reported. When released to surface soils, xylene will volatilize to the atmosphere or leach into the subsurface. Some photo-induced oxidation may also take place on soil surfaces. Biodegradation of xylenes is slow with the o-xylene showing the least degradation. Xylene's mobility in soil is highest in dry, nonorganic soils (ATSDR, 1993a). Bioconcentration factors for o-, m-, and p-xylenes have been estimated to be 45, 105, and 95 respectively which indicate a slight tendency of xylene to bioconcentrate (ATSDR, 1993a).

Semivolatile Organic Compounds

Butyl Benzyl Phthalate

Like other phthalate esters, butyl benzyl phthalate would be expected to adsorb to soils and sediments ($\log K_{oc}$ 2.2) and not leach extensively. Volatilization is not usually a significant process (Howard, 1989). The most significant removal process for butyl benzyl phthalate from soil, sediment or surface water is biodegradation. With a $\log K_{ow}$ of 4.91 this compound is expected to bioconcentrate in aquatic organisms. A BCF of 663 has been reported for bluegill sunfish (Howard, 1989).

1,4-Dichlorobenzene, 1,2-Dichlorobenzene

With partition coefficient values ($\log K_{oc}$) of 2.44 to 3.26 in different soils, 1,4-dichlorobenzene will sorb to soils (especially organic soils) and sediments and persist there (Howard, 1989). Sorption is likely to be reversible in some soils, which would allow 1,4-dichlorobenzene to leach to ground water. Volatilization will also occur from surface soils and surface water. The $\log K_{ow}$ value of 3.39 suggests that 1,4-dichlorobenzene has a high potential for bioaccumulation. Biodegradation to inorganic end products can occur under aerobic conditions (ATSDR, 1993b). No specific environmental fate data was located for 1,2-dichlorobenzene but with similar $\log K_{oc}$ (2.27) and $\log K_{ow}$ (3.38) values (Montgomery, 1996), fate and transport should be similar to that of 1,4-dichlorobenzene.

Di-n-butyl Phthalate

Di-n-butyl phthalate has been retained as a COPC since no screening level values could be located. Adsorption onto soil and sediments appears to be a significant sink for di-n-butyl phthalate. It is degraded both in soils and sediments under aerobic and anaerobic conditions (ATSDR, 1997). Di-n-butyl phthalate has low volatility and is only slightly soluble in water, but may be transported in water following formation of chemical complexes with humic substances. Di-n-butyl phthalate can be taken up by a variety of organisms including invertebrates, fish and some plant seedlings (ATSDR, 1997).

Bis(2-Ethylhexyl)Phthalate

If introduced to soil, bis(2-ethylhexyl)phthalate (BEHP) would be expected to strongly adsorb to both mineral and organic soils. BEHP degrades in soil under aerobic conditions, but slowly if at all under anaerobic conditions. In water BEHP adheres strongly to suspended solids and sediments (ATSDR, 1989). BEHP bioaccumulates in both plants and animals ($\log K_{ow}$ 4.88). The tendency for biomagnification is somewhat reduced by the metabolism of BEHP in invertebrates, fish and other animals (ATSDR, 1989).

Isophorone

Isophorone has been retained as a COPC since no screening level value could be located. If released to soil or water, isophorone is predicted to be removed partially by volatilization and partially by biodegradation. Isophorone can leach through soil to ground water and would not be expected to adsorb to soils or sediments ($\log K_{oc}$ 1.49) or significantly bioaccumulate in aquatic organisms (BCF 7) (Howard, 1990).

Naphthalene and 2-Methylnaphthalene

Naphthalene and 2-methylnaphthalene should be slightly mobile to immobile in soils ($\log K_{oc}$ 2.97 and 3.39 respectively). The extent of sorption increases with increasing soil organic content (ATSDR, 1993c). Naphthalene and 2-methylnaphthalene would remain largely in solution when discharged to surface waters. The BCFs for naphthalene and 2-methylnaphthalene of 40 to 1000 and 100 to 631 respectively indicate a moderate to low tendency to bioconcentrate in aquatic organisms, however these compounds are also metabolized and excreted (ATSDR, 1993c).

Phenol

If phenol is released to soil or surface water it will biodegrade rapidly under aerobic conditions. Despite its high solubility (87,000 mg/l) and poor adsorption on soil, biodegradation is sufficiently rapid that most ground water is generally free of phenol. The exception would be in the cases of spills where high concentrations of phenol destroy degrading microbial populations. Some phenol would evaporate from soils (Howard, 1989). In aquatic environments phenol would not be expected to hydrolyze, adsorb to sediments or bioconcentrate in aquatic organisms. Under aerobic conditions biodegradation will be the significant fate process (Howard, 1989).

1,2,4-Trichlorobenzene

If released to soil 1,2,4-trichlorobenzene (1,2,4-TCB) is expected to adsorb to the organic matter in soil and therefore should not leach appreciably to ground water. It will not hydrolyze but may biodegrade slowly in soil, but not in ground water (Howard, 1989). 1,2,4-TCB should adsorb to sediments if released to surface water and may bioconcentrate (BCF values range from 51 to 2800). 1,2,4-TCB should also be subject to some biodegradation and evaporation from surface waters (Howard, 1989).

Metals

Cadmium

In soils, cadmium may leach into ground water especially under acidic conditions. Cadmium containing soil particles can partition to the air or surface water. Cadmium is more mobile in aquatic environments than most other heavy metals and usually exists as the hydrated ion ($\text{Cd}^{+2} 6\text{H}_2\text{O}$) (ATSDR, 1993e). Precipitation and sorption to mineral surfaces and organic materials are the most important removal processes for cadmium compounds. Cadmium bioaccumulates in all levels of the food chain, from grasses and food crops to large mammals. However, since cadmium accumulates largely in the liver and kidneys of vertebrates and intestinal adsorption of cadmium is low, biomagnification through the food chain may not be significant (ATSDR, 1993e).

Lead

The fate of lead in soil is affected by the specific or exchange adsorption at mineral interfaces, the precipitation of sparingly soluble solid forms of the compound, and the formation of relatively stable organic-metal complexes or chelates with soil organic matter. These processes are dependent on

such factors as soil pH, organic matter content of soil, the presence of inorganic colloids and iron oxides, ion-exchange characteristics, and the amount of lead in soil (ATSDR, 1993f). Most lead is retained strongly in soil and very little is transported into ground water. It may enter surface water through erosion. However, at a pH of 4-6, organic lead complexes become soluble and leach out or may be taken up by plants. If the lead concentration exceeds the cation exchange capacity of the soil, leaching may also occur. Plants and animals may bioconcentrate lead but biomagnification has not been detected. Lead is toxic to all aquatic biota (ATSDR, 1993f).

The transport of lead in the aquatic environment is influenced by the speciation of the ion. The available information indicates that fish bioaccumulate very little lead in edible tissues; however, oysters and mussels may accumulate lead at elevated levels. Lead can be methylated by microorganisms present in lake sediments. The volatile compound resulting from biomethylation, tetramethyl lead, probably leaves the sediments and is either oxidized in the water column or enters the atmosphere. Thus, lead may enter the aquatic environment from contaminated sediments. Based upon the limited quantitative data available for lead, photolysis, oxidation, volatilization, and hydrolysis are considered to be environmentally insignificant fate processes (ATSDR, 1993f).

Zinc

Zinc is likely to sorb strongly to soil, sediments, and suspended particles. Its mobility depends on the solubility of the speciated forms of the compound and on soil properties such as cation exchange capacity, pH, redox potential, and species present in soil. Under anaerobic conditions, zinc sulfide is the controlling species, which is insoluble and therefore immobile (ATSDR, 1992b). In general, zinc is more mobile in acid soil conditions but the relation is complex and depends on soil organic content, redox potential and cation exchange capacity. Wind-blown dust containing entrained zinc can also transport zinc to the atmosphere. Zinc has been shown to bioconcentrate in aquatic organisms but does not appear to biomagnify in the food chain. No evidence of biodegradation of zinc in the environment is noted in the literature (ATSDR, 1992b).

Pesticides and PCBs

Aroclor (PCB)

PCBs are persistent in soils containing moderate to high levels of organic matter. Heavily chlorinated PCBs persist longer and degrade slower than

lightly chlorinated PCBs. PCBs are known to bioaccumulate readily in adipose tissues, especially in interstitial organisms. In aquatic media, PCBs tend to volatilize, after which they may be slowly photolyzed in the atmosphere. Aquatic invertebrates are important in the cycling of PCBs within the aquatic environment and between aquatic and terrestrial ecosystems (Eisler, 1986).

Biotransformation and biodegradation are important fate processes for the mono-, di-, and tri-chlorinated biphenyls; are of intermediate importance for tetrachlorinated biphenyls; and are of no importance for penta- and higher chlorinated biphenyl's which are completely resistant. Sorption, volatilization (aerosol distribution followed by fallout with dust or rain and fugitive dust emissions), and bioaccumulation are other important fate processes. PCBs strongly sorb to sediments and/or suspended particles, resulting in extremely long half-lives (52.5 days) and making desorption a possibility for years to come. Volatilization of PCBs results from fugitive dust emissions (half-life 10.4 hours). PCBs strongly bioaccumulate in the food chain through desorption from sediments and direct uptake by plants and other aquatic species.

6.2.2

Exposure Pathways and Potential Receptors

The primary exposure pathways associated with the Greiner's Lagoon Site are direct contact (dermal and ingestion) with contaminated surface soil, sediment or surface water. Most of the Consolidation Area is bare of vegetation and shows signs of erosion. During periods of dry weather, heavy winds from the broad, flat, surrounding area could create fugitive dust which could be inhaled. During times of high rainfall, exposure could also occur via surface water runoff. It is important to note, however, that as part of a removal action in 1987, the USEPA installed a clean soil cover over the Consolidation Area. Thus, wind and surface water runoff from the soil cover are not likely to disperse affected material.

Potential ecological receptors at Greiner's Lagoon Site have been identified through characterization of the terrestrial community as described in Section 6.1.1. Potential uses of site habitats by ecological receptors would include nesting, resting, burrowing, and food gathering. Determination of realistic potential receptors to possible contamination at the Site is based on utilization of habitats by wildlife.

Birds which build nests above ground, rest on vegetation, or gather food from the air (insects) would not be likely receptors. Moles, other burrowing rodents, and soil invertebrates are potential receptors. Birds such as robins, which consume soil invertebrates, or hawks, which

consume rodents, are also possible receptors. However, no rodent burrows or soil invertebrates were observed during the Site reconnaissance in the Consolidation Area. Two of the constituents of potential concern (bis[2-ethylhexyl] phthalate and Aroclor 1254) can bioconcentrate and biomagnify within food chains and could therefore affect such species as robins, hawks or moles.

Aquatic organisms in the nearby drainage channel could also be affected during times of high rainfall. Although the fence would not exclude most wildlife, species such as white-tailed deer and rabbits are not likely to be affected since there is little vegetation within the fenced area of contamination to attract them. Thus, only transient exposure of these species is expected.

6.2.3 Preliminary Analysis of Ecological Risk

Ecotoxicological Benchmark Values

A preliminary ecological risk assessment (PERA) is based on comparing maximum concentrations of detected constituents with screening levels by media. This PERA utilized the screening values in *Evaluating Soil Contamination* (Beyer, 1990) and *Oak Ridge National Laboratory (ORNL) Screening Levels* (1996 and 1997).

6.2.3.1 Exposure Estimates

This PERA was performed with the following conservative assumptions:

- 100% Bioavailability,
- 100% Area use factor, and
- Use of maximum constituent concentration detected.

Comparisons of the maximum concentrations of constituents with screening levels are given in Tables 6-5 (on-site soil), 6-5a (off-site soil) and 6-7 (surface water and sediment).

6.3 RISK CHARACTERIZATION

6.3.1 Discussion of Risk

Twenty (20) constituents in on-site soil, surface water or sediment have an EEQ greater than one. The constituents of potential concern identified in on-site soil are found predominantly in the Consolidation Area. Most of the Consolidation Area is bare of vegetation and shows signs of erosion.

These areas are presenting either a physical or chemical stress to plant life. The pathways discussed in Section 6.2.2 may create a potential risk for some ecological receptors such as robins, hawks, small rodents and soil invertebrates. However, since surface soil impacts in the Consolidation Area are limited in size and the area lacks vegetation, wildlife will not spend a significant amount of time in the area because there are no sources of food or cover to attract wildlife species. In addition, it is important to note that as part of a removal action in 1987, the USEPA installed a clean soil cover over the Consolidation Area. Thus, no affected material should be available for exposure, except for limited areas where this cover may have been breached.

Surface water runoff appears to leave the Site only during times of high or prolonged rainfall. Surface runoff from the Site flows toward the east and west sides of the Site, including toward the Marsh Area and Wooded Area B on the west side. Receptors in these areas could potentially be at risk through direct contact and food chain exposures from runoff and sediment. However, off-site soil samples collected from Wooded Area B (GL-SS-GB-15 and GL-SS-BG-17) did not have any constituents detected above screening levels.

Surface water can also leave the site via an underground drainage pipe at the northeast corner of the Site. This pipe drains into a nearby drainage channel and could potentially carry contaminants from the site during times of high rainfall. However, surface water and sediment samples collected from this drainage channel indicate that only low levels of constituents of potential concern had reached this channel, as discussed below.

Surface water samples from the drainage channel contained almost no constituents of potential concern. One sample contained a low concentration of lead and one sample contained bis(2-ethylhexyl)phthalate. Both of these concentrations were estimated below the laboratory's detection limit and were detected in the duplicate samples only. Both were detected only slightly above their screening levels (Table 6-7). Sediment samples from the channel contained nine different constituents of potential concern but only acetone was detected above the available screening levels (Table 6-7). Acetone volatilizes rapidly and is not expected to pose a significant ecological risk. Neither the drainage channel or Indian Creek appear to support a strong aquatic community. Both water systems have been channelized with steep banks, and deepened. The fields adjacent to the waterways have been farmed to the edge of the systems, and the drainage courses have no vegetative cover.

The volatile organic constituents of potential concern all tend to volatilize from soils but do not strongly adsorb to soils and are therefore subject to leaching. These compounds volatilize from surface water and therefore pose little threat to aquatic communities. These compounds have relatively low bioconcentration factors and would not be passed through the food chain. Toluene and xylenes(total) occurred at the highest concentrations in on-site soil with EEQs greater than 100.

Butyl benzyl phthalate, di-n-butyl phthalate, and bis(2-ethylhexyl)phthalate are all semivolatile organic compounds that can bioconcentrate in organisms. Volatilization is a major fate process for 1,2-dichlorobenzene, 1,4-dichlorobenzene and isophorone. Butyl benzyl phthalate, di-n-butyl phthalate, bis(2-ethylhexyl)phthalate, isophorone, and phenol are all subject to biodegradation.

Naphthalene and 2-methylnaphthalene are only slightly mobile in soils and can bioconcentrate in aquatic organisms, but these compounds are metabolized and rapidly excreted by fish and shellfish when they are removed from polluted waters. 1,2,4-Trichlorobenzene adsorbs to soils and shows a slight tendency to bioconcentrate in aquatic organisms but is also subject to biodegradation in both terrestrial and aquatic environments.

The metals cadmium, lead, selenium, and zinc, were detected in on-site soil samples. In samples from the stabilized material, values were above screening levels for all four metals at SM-8. At SM-7 screening values were exceeded for cadmium and lead. Both of these areas have received erosional sediment due to surface water runoff from the Consolidation Area. All four metals have been shown to bioconcentrate in organisms. Wind-blown soils with entrained metals can be an exposure risk. None of the metals had EEQs greater than nine.

6.3.2

Uncertainty

There are a number of difficulties involved in the prediction of ecological risk, and a critical part of any risk evaluation is an assessment of the potential uncertainties associated with the analysis. In this evaluation, some of the specific uncertainties included many conservative assumptions which result in a worst case screening. Wild populations of animals are not likely to receive maximum exposure because they are free to roam and inhabit areas more suitable to their needs. Exposure to worst case conditions should they exist, will likely be intermittent.

CONCLUSIONS

The habitats and associated wildlife observed on the Greiner's Lagoon Site are typical of the predominantly agricultural land use of northwest Ohio. The results of the terrestrial survey indicated that the area of stabilized material is largely unvegetated with areas of erosion. The Marsh Area and Wooded Area B covertypes to the west of this bare area do receive surface water runoff and soil from the former lagoon site. It is important to note, however, that as part of a removal action in 1987, the USEPA installed a clean soil cover over the Consolidation Area. Thus, wind and surface water runoff from the soil cover are not likely to disperse affected material. Thus, no affected material should be available for exposure, except for limited areas where this cover may have been breached. In addition, exposure of ecological receptors in these areas will be limited due to the limited size of the impacted area and the lack of wildlife attractant value (food or cover resources).

A formal wetland delineation was not conducted as part of the Site reconnaissance. However, the total potential wetland area on the west side of the Site receiving surface water runoff from the Consolidation Area is estimated to be less than one acre. The drainage ditch on the east side of the Consolidation Area which also receives surface water runoff is not likely to be classified as a jurisdictional wetland by the Army Corps of Engineers. Thus, these areas would not be subject to regulation under the Army Corps of Engineers or the Ohio EPA Division of Surface Water Quality (Personal Communication, John Mack, Ohio EPA Division of Surface Water Quality, 1999). In addition, no constituents of potential concern were identified in soil samples collected from Wooded Area B.

The underground pipe connection of the ditch area with the nearby drainage channel could pose a potential risk to the aquatic community in the channel during times of high or prolonged rainfall. Indian Creek communities could also potentially be at risk. However, samples of the surface water and sediment from the nearby drainage channel indicate little impact from the Site. In addition, neither the drainage channel nor Indian Creek contain suitable habitat for aquatic communities. There are little or no riffle areas, vegetative cover, or other cover in the waterways. The fields adjacent to the watercourses are farmed to the edge and the waterways have been channelized and deepened with steep banks.

The State of Ohio and the US Fish and Wildlife Service were contacted regarding the known presence of state and federal threatened or endangered species at the Site (Appendix L). None were observed during the Site reconnaissance and none should be impacted because of the Site size and location. A fish species of special interest has been

predominantly found in the Sandusky River more than 5 miles upstream of the Site. Four species of plants and animals of interest also have been found in Sandusky County, but none have been observed in the vicinity of the Site.

Seepage from the stabilized material was corrected in 1997 and 1998. In addition, and as mentioned previously, USEPA installed a clean soil cover over the Consolidation Area. Thus, no affected material should be available for exposure, except for limited areas where this cover may have been breached. While the maximum concentrations of chemical constituents indicate that some level of potential ecological risk exists, due to the limited size of the Consolidation Area, the inaccessible nature of the affected materials, and the lack of optimal habitat features (little to no vegetative cover, thus no food source or attractant value), exposure is suspected to be small. Likewise due to the over-estimate of potential impacts as a result of the conservative assumptions of 100% bioavailability and 100% use, the potential risk of the Site to regional species would be significantly less than indicated by EEQ values.

SCOPE AND OBJECTIVE OF REMOVAL ACTION

Based on the results of the site investigations and risk assessments, the objective and scope for the non-time critical removal action at the Greiner's Lagoon Site is to mitigate the risks to human health and the environment as defined in the streamlined risk assessment described herein in Section 5.0.

The human health risk assessment identified the following risks slightly above U.S. EPA thresholds for the Site:

- Carcinogenic Risks - Exposure of On-Site Soil to the Future Construction Worker and Adolescent Trespasser
- Non-Carcinogenic Risks - Exposure of On-Site Soil to the Future Construction Worker and Exposure of On-Site Shallow Ground Water to the Future Construction Worker

In summary, there are no unacceptable off-site risks at the site.

The removal action will provide for short- and long-term minimization of the potential for human and biota exposure to constituents of concern at levels which would result in calculated risks above U.S. EPA thresholds for the site. The removal action will be implemented to the extent practicable in accordance with applicable, or relevant and appropriate requirements (ARARs) as further discussed in Section 8.5.

PLANNED REMOVAL ACTION ACTIVITIES

Several removal action alternatives have been developed for the site, which are further discussed herein. The removal action alternatives vary in scope, but all include engineering controls required to meet the removal action scope and objectives as described above. The removal activities will include final design of the selected alternative, removal action implementation, long term operation and maintenance, as well as performance monitoring (as appropriate).

SCHEDULE FOR REMOVAL ACTION

The non-time critical removal action at the Greiner's Lagoon Site will be completed in accordance with the U.S. EPA Guidance upon completing such removal actions under CERCLA. The non-time critical removal action process includes the completion of the EE/CA followed by an EE/CA approval memorandum which will be issued by the U.S. EPA. The approval memorandum and EE/CA will be subject to public comment during a 30-day public review period. The U.S. EPA will provide public notice of such review period. Following the public comment period, the U.S. EPA must prepare a written response addressing significant comments received during the review period. The U.S. EPA will then issue an Action Memorandum which will record the decision to select an appropriate removal action for the Greiner's Lagoon Site. The Action Memorandum will include a summary of the proposed action and schedule for its implementation.

Each of the removal action alternatives presented herein include an estimated time for implementation. The schedule, however, will be subject to completion and approval of the final design, weather constraints during construction or implementation, availability of materials, etc.

8.0

DEVELOPMENT AND EVALUATION OF REMOVAL ACTION ALTERNATIVES

As detailed in Sections 5.0 and 6.0, the Greiner's Lagoon Site poses a small potential risk to future construction workers from exposure to the consolidated materials and impacted soil, and to hypothetical ecological receptors from storm water run-off. Based on the results of the site investigations and the risk assessments, U.S. EPA guidance documents and engineering judgment, various potentially applicable removal action technologies are identified to address the potential risk by containment, treatment, and/or disposal of consolidated material and impacted soil at the Site. The removal action technologies are screened to eliminate those that may be infeasible to implement or that have inherent limitations for the Site.

8.1

SCREENING CRITERIA

The candidate removal action technologies are screened using the following criteria:

- Effectiveness;
- Implementability; and
- Cost.

Effectiveness addresses to what extent a technology can protect human health and the environment and to what degree it may achieve the defined removal action objective. Implementability is a measure of the technical (e.g., ability to construct and operate) and administrative (e.g., ability to obtain necessary permits and approvals) feasibility of constructing, operating, and maintaining that technology. The evaluation of cost focuses on estimates of relative costs so that the technologies can be evenly compared.

8.2

SCREENING OF TECHNOLOGIES

Potential technologies for addressing the potential risks at the Site are identified below:

Miscellaneous

No Action

Access Control

Containment Technologies

Engineered Clay Cap

OAC 3745-27-11 Cap

RCRA Multi-layer Cap

Phytoremediation (Cover)

Treatment Technologies

Soil Physical Solidification

Soil Chemical Stabilization

Thermal Desorption

Incineration

Biological Treatment

Monitored Natural Attenuation

Phytoremediation (Treatment)

Disposal

Excavation

On-site Landfilling

Off-site Landfilling

The following sections describe the potential removal action technologies, their limitations, and the screening results.

8.2.1

No Action

Technology Summary

No additional measures would be undertaken to address the potential risks posed by the consolidated materials and impacted soil.

Screening Results

The No Action alternative will be eliminated from further consideration.

8.2.2 Access Control

Technology Summary

Access to the Site could be controlled by improving the fencing, increasing security measures, and/or implementing deed restrictions.

Screening Results

Access control would be an effective method for reducing the potential risk of humans or ecological receptors coming into contact with Site conditions such as the consolidated material and impacted soil. The cost is expected to be relatively low.

Access control would include upgrading the fence and installing a security system to detect vehicular access to the Site. This would be an effective method for reducing the potential risk of humans or ecological receptors coming into contact with site conditions such as the consolidated material and impacted soil. Deed restrictions can be used to prohibit Site uses that would result in exposures to the constituents of concern.

Access control will be retained for further evaluation as a removal technology.

8.2.3 Engineered Clay Cap

Technology Summary

An engineered clay cap typically consists of a multi-layer system with a 12-inch layer of native material at the bottom to level the surface of an area such as the Consolidation Area at the Site. On top of the native material, a 12-inch thick, compacted clay layer (hydraulic conductivity of 10^{-7} cm/sec or less) would be constructed in multiple lifts, using engineering controls. Above the clay barrier layer would be 2 feet of common soil and topsoil with vegetative cover. The cap would be sloped for proper drainage and periodic maintenance of the cover would be required.

Screening Results

This type of cap is a proven containment technology that can be readily implemented and installed using well-known, conventional construction techniques. It would be effective in eliminating human and ecological receptor contact with the impacted soil at the Site and the transport of soil particles by precipitation and wind. This technology is expected to have low costs. The engineered clay cap is retained for further consideration as a removal action technology.

8.2.4 OAC 3745-27-11 Cap

Technology Summary

An OAC 3745-27-11 cap consists of a multi-layer system with a recompacted soil barrier layer, minimum of 2 feet thick at the bottom to level the surface of an area such as the Consolidation Area at the Site. On top of the native material, a 12-inch thick granular drainage layer would be constructed. Above the drainage layer would be a vegetative layer consisting of soil and vegetation. The applicable regulations allow for "comparable material and/or thickness for the soil barrier layer, granular drainage layer, and soil vegetative layer" if approved by the Ohio Director of Solid Waste. This provision for the alternate design was utilized. An August 27, 1998 meeting with Ohio EPA, US EPA and Lubrizol representatives resulted in consideration of a cap design including a 12 inch prepared base, FML/GCL combination, drainage layer, 18 inches of rooting zone soil, and 6 inches of topsoil. The cap would be sloped for proper drainage and periodic maintenance of the cover would be required.

Screening Results

This type of cap is a proven containment technology that can be readily implemented and installed using well-known, conventional construction techniques. It would be effective in eliminating human and ecological receptor contact with the impacted soil at the Site and the transport of soil particles by precipitation and wind. This technology is expected to have low costs. The OAC 3745-27-11 Cap is retained for further consideration as a removal action technology.

8.2.5

RCRA Multi-layer Cap

Technology Summary

This technology involves covering the consolidated materials and impacted soil with a system of soil and geosynthetic layers. A RCRA multi-layer cap typically would have a compacted, low permeability soil layer (hydraulic conductivity of 10^{-7} cm/sec or less) that is 2 feet thick, a geomembrane such as VLDPE, and a 1-foot thick drainage layer covered by a geofabric filter. Above these layers would be a 2-foot layer of common soil and top soil with vegetative cover. The cap would be sloped for proper drainage and periodic maintenance of the cover would be required.

Screening Results

RCRA multi-layer capping is a proven containment technology and can be readily implemented. It would be effective in eliminating human and ecological receptor contact with the soil and transport of soil particles by precipitation and wind. A RCRA multi-layer cap is expected to have moderate costs compared to other removal action technologies. However, a RCRA cap would have a significantly higher cost than an engineered clay cap without any additional benefit in meeting the removal action objective. Therefore, the RCRA multi-layer cap is eliminated from further consideration.

8.2.6

Phytoremediation (Hydraulic Control)

Technology Summary

A phytoremediation-based cover uses a vegetative cover over the soils to act as a deterrent to soil erosion, to control or eliminate percolation through enhanced evapotranspiration, to chemically stimulate natural degradation, and to promote the degradation of organic constituents, and absorption/extraction of metal constituents.

A phytoremediation-based cover prevents soil erosion by reducing the physical force of raindrops that loosen soil particles when they strike bare soil, and allow particles to be carried off as suspended matter in runoff. The interwoven network of roots in the upper layers of soil are also important in holding soil in place to prevent erosion.

This cover would also control or eliminate percolation through the process of evapotranspiration. This process is the result of two events, both of which are dependent on the magnitude of the leaf surface area. Plant

leaves intercept falling rain and a portion of it remains suspended on the leaf surfaces until it evaporates back into the atmosphere. As a result, light rain falling on dense tree canopies never reach the soil surface. During periods of heavy rain when leaf surfaces become saturated, the excess water drips to the ground and soaks into the porous surface soil where it is subject to uptake by plant roots and subsequent return to the atmosphere through plant transpiration. The amount of water lost to the atmosphere by transpiration from an individual plant is directly dependent on plant biomass. A plant with a large leaf surface area and spreading root system has a large plant biomass.

A tree barrier can also be established which will provide hydraulic control of the shallow ground water by minimizing the amount of ground water that migrates off site.

Phytoremediation technology associated with constituent treatment is discussed in Section 8.2.12.

Screening Results

This technology is a recognized innovative containment technology. Based on results obtained thus far at sites that have been using this technology, the cover effectively reduces human and ecological receptors at the Site, and the transport of soil particles by precipitation and wind. A Phytoremediation Feasibility Study was performed on the site, which concluded that this technology could be used at the site (see Appendix M). This technology is expected to have low costs. The phytoremediation-based cover is retained for further consideration as a removal action technology.

8.2.7 *Soil Physical Solidification*

Technology Summary

This technology involves mixing materials such as clean soil, flyash, lime, etc. with the Site consolidated material in selected areas to improve the engineering properties of the consolidated material, where necessary, to ensure that there is adequate support for a cap. Solidification costs are estimated to be \$30 per ton.

Screening Results-Greiner's Lagoon

ERM collected 22 Shelby tubes during the advancement of the stabilized material soil borings. These borings were performed to collect geotechnical strength data on the subsurface material in the stabilized lagoon area. Upon laboratory receipt of the tubes, it was determined that

only 7 tubes had adequate sample volume or were in an undamaged condition.

The material contained within these 7 tubes demonstrated significant variability within and across the sample length. ERM attempted to perform triaxial shear analysis on 5 sample recovered from the tubes. During performance of the tests and reduction of the data the material demonstrated sufficient variability as to invalidate any results obtained. The remaining two samples disintegrated upon extrusion from the tube leaving no salvageable material for analysis.

As such, ERM utilized blow count data to demonstrate the in-situ strength of the stabilized material. Review of the blow count data, indicate a similar pattern of strength for two groups of stabilized material borings.

The SM1 through SM4 borings at the north end of the Consolidation Area showed a similar pattern of strength prior to reaching natural material. Depths from 0 to 15 feet indicated a soft to medium consistency materials generally equating to an unconfined compressive strength of 3 psi to 14 psi. Depths of 15 to 20 feet showed a very stiff consistency materials equating to an unconfined compressive strength of 28 to 55 psi.

The SM5 through SM8 borings at the south end of the Consolidation Area showed a similar pattern of strength prior to reaching natural materials. Depths from 0 to 7 feet showed a stiff consistency material equating to an unconfined compressive strength of 14 to 28 psi. Depths of 7 to 11 feet showed a very stiff consistency material generally equating to an unconfined compressive strength of 28 to 55 psi. Depths of 11 to 16 feet showed a stiff to very stiff consistency materials generally equating to an unconfined compressive strength of 14 psi to 42 psi.

Kriging techniques applied to blow-count information resulted in a determination that approximately 10,000 cubic yards of soft consistency materials would require solidification to support with a factor of safety of 2.0 the ORC 3745-27-11 cap.

Screening Results - General

The technology is well-documented and would be effective for improving, as needed, the strength of the consolidated materials. See Appendix N: Case Studies – Solidification/Stabilization of Oily Materials. Additionally, Lubrizol performed a Treatability Study, which concluded that physical solidification could be used at this site (see Appendix O). The cost for physical solidification is expected to be relatively low. Hence, soil physical solidification is retained for further consideration.

Technology Summary

Chemical stabilization is a process of fully or partially bonding the chemicals of concern in soil by mixing additives with the soil. The additives are typically cement-based or pozzolanic-based materials. The additives can be mixed with soil in-situ, even at significant depth, using large diameter augers. In the alternative, the soil can be excavated and mixed with the stabilizing agent prior to placement back in the excavation. Treatment costs are estimated to be \$43 per ton.

Screening Results

Soil chemical stabilization can be used to reduce the potential leaching of chemicals of potential concern from the consolidated materials and impacted soil. Chemical stabilization has been successfully used on soil contaminated with organics and on organic wastes. See Appendix N: Case Studies - Solidification/Stabilization of Oily Materials. It would be effective for improving, as needed, the strength of the consolidated materials. The cost is expected to be moderate to high. Soil chemical stabilization is retained for further consideration as a removal technology.

Technology Summary

Low temperature thermal desorption (LTTD) is a process whereby volatile and semivolatile organic-contaminated materials are heated at elevated temperature in order to evaporate and/or desorb contaminants from the medium without causing their combustion. Treatment costs are estimated to range from \$80 to \$120 per ton.

Screening Results

High moisture content increases the heat load required to drive off moisture while maintaining operating temperatures. In addition, potential for production of toxic materials such as furan and dioxins are possible. Furthermore, very fine soils such as silts and clays may adhere to process equipment and decrease system efficiency or interrupt treatment completely. The technical feasibility of this technology is doubtful for the Site. Consequently, thermal desorption is eliminated from further consideration.

8.2.10

On-Site Incineration

Technology Summary

Incineration involves the thermal destruction of organic contaminants at temperatures greater than 1,500 degrees F in the presence of oxygen, which causes volatilization, combustion, and destruction of the contaminants. After the incineration process, flue gas rising from the furnace is consumed in an afterburner, and typically is allowed to cool before passing through a cyclone unit. The cyclone unit captures fugitive dust that settles into a baghouse. Off-gases then pass through air pollution control devices. Treatment costs are estimated to range from \$100 to \$290 per ton.

Screening Results

High moisture content increases the heat load required to drive off moisture while maintaining operating temperatures. In addition, potential for production of toxic materials such as furan and dioxins are possible. Furthermore very fine soils such as silts and clays may adhere to process equipment and decrease system efficiency or interrupt treatment completely. The technical feasibility of this technology is doubtful for the Site. Consequently, on-site incineration is eliminated from further consideration.

8.2.11

Biological Treatment

Technology Summary

Biological treatment involves enhancing the natural process of degradation of organic contaminants by microbial populations in the consolidated materials and impacted soil. It usually entails modification of the materials' moisture, oxygen, and nutrient levels by the injection or mixing of additives. Treatment costs are expected to range from \$50 to \$260 per ton.

Screening Results

From a review of the literature, it appears that the bio-drop system should not be used for clay or heterogeneous subsurface environments because of oxygen transfer limitations. Moreover, potential flow path (heterogeneous nature of materials at the Site) may severely decrease contact between injected fluids and contaminants. The technical feasibility of this technology is doubtful for the Site. Consequently, this form of biological treatment is eliminated from further consideration.

8.2.12 Phytoremediation (Treatment)

Technology Summary

Phytoremediation is a form of biological treatment which is used to remediate soil or water media. This technology was previously discussed in Section 8.2.6 for its ability to be used for hydraulic control. This cover can also be used as a treatment technology by chemically stimulating natural degradation and promoting the degradation of constituents.

Contaminants that have high water solubility and low log Kow will be prone to be taken up by plants and metabolized in various tissues along the path that the contaminant follows from root to leaf. If the contaminant is both water soluble and volatile, it can also be emitted into the atmosphere if its concentration in the soil is large enough. If the contaminant has a low water solubility and high log Kow, its relative rate of being taken up by the plants is slower. Some plant compounds have naturally occurring substrates that promote the growth and activity of bacteria capable of degrading these compounds. By using these plants, natural degradation of these compounds can occur. Additionally, the natural process of root growth and death in the subsoil causes pathways for oxygen to enter the soil further promoting degradation of some constituents.

Screening Results

This technology is a recognized innovative treatment technology. Based on results obtained thus far at sites that have been using phytoremediation, this technology would effectively reduce organic and metal constituent concentrations in soil and ground water media at the Site. A Phytoremediation Feasibility Study was performed on the site, which concluded that this technology could be used at the site (Appendix M). This technology is expected to have low costs. Phytoremediation is retained for further consideration as a removal action technology.

8.2.13 Monitored Natural Attenuation

Technology Summary

Monitored natural attenuation is a technology that relies on natural attenuation processes to achieve site-specific remedial objectives. The natural attenuation process includes a variety of physical, chemical, or biological processes that act without human intervention to reduce mass, toxicity, mobility, volume or concentration of constituents of concern in soil or ground water. These processes include biodegradation, dispersion, dilution, sorption, volatilization, and transformation.

Screening Results

Monitored natural attenuation is an effective method to ensure that the potential risk of humans or ecological receptors coming into contact with the shallow saturated zone will continue to be below risks calculated for the Site. The cost of the technology is expected to be low. Monitored natural attenuation will be retained for further evaluation.

8.2.14 *Excavation*

Technology Summary

Excavation of impacted soil is commonly combined with treatment and/or disposal as a method for addressing potential risk posed by constituents of concern. Excavation technology is well-demonstrated and readily available.

Screening Results

Excavation can be combined with other removal technologies to effectively address the potential risks at the Site. The possible need for dust/odor control during excavation would have to be considered. The cost of the technology is expected to be low to moderate. Excavation will be retained for further evaluation.

8.2.15 *On-Site Landfilling*

Technology Summary

This technology consists of on-site disposal of consolidated material and impacted soil in an engineered landfill with liners and a cap. Because of the size of the Site, material to be disposed would have to be excavated and stored on-site or off-site nearby while the landfill cell is constructed. Waste would then have to be placed in stages and brought to grade prior to placement of the cap.

Screening Results

Disposal of the consolidated material and impacted soil in a landfill constructed on-site would effectively minimize the potential for humans or ecological receptors to come into contact with the chemicals of potential concern. However, implementation would be very difficult and the costs are expected to be very high. Therefore, on-site landfilling will be eliminated from further consideration.

Off-Site Landfilling

Technology Summary

This technology entails transportation and disposal of contaminated materials in a permitted, off-site landfill with appropriate engineering controls.

Screening Results

Off-site landfilling is a well-proven technique for minimizing the on-site risk presented by chemicals of potential concern. Although the results of the Site investigations suggest that most of the consolidated material is expected to be non-hazardous solid waste, it is still possible that some of the materials would have to be landfilled as hazardous waste. The cost for this technology is expected to be high. Off-site landfilling will be retained for additional evaluation as a potential removal action.

SCREENING SUMMARY

"Screening of Technologies" identified six potential treatment technologies for addressing potential risks at the Site. These treatment technologies included Soil Physical Solidification, Soil Chemical Stabilization, Biological Treatment, Thermal Desorption, Incineration and Phytoremediation.

Table 8-1 presents a summary of comparative criteria for each of the six treatment technologies. The relative technological attractiveness of each alternative is indicated with either a +, 0 or -. The relative cost attractiveness of each alternative is indicated by the estimated treatment costs per ton. Based upon their relative technological and cost attractiveness, only three treatment technologies Soil Physical Solidification, Soil Chemical Stabilization and Phytoremediation were carried forward into Section 8.4 as components for removal action alternative evaluations.

As such, the following removal action technologies are retained for further evaluation in the EE/CA:

- Access Control
- Engineered Clay Cap
- OAC 3745-27-11 Cap

- Soil Physical Solidification
- Soil Chemical Stabilization
- Excavation
- Off-site Landfilling
- Phytoremediation (Hydraulic Control and Treatment)
- Monitored Natural Attenuation

8.4

EVALUATION OF REMOVAL ACTION ALTERNATIVES

This section of the EE/CA identifies and provides a detailed evaluation of removal action alternatives developed from the technologies remaining after the screening process. The alternatives address reduction of potential risk at the Greiner's Lagoon Site. In assembling the alternatives, various removal action technologies are combined in different ways. The removal action alternatives to be evaluated are presented below:

Alternative 1: Engineered Clay Cap; Selective Soil Physical Solidification; Access Control; Monitored Natural Attenuation

Alternative 2: Engineered Clay Cap; Soil Chemical Stabilization; Access Control; Monitored Natural Attenuation

Alternative 3: Excavation; Off-site Landfilling; Access Control

Alternative 4: OAC 3745-27-11 Cap, Selective Soil Physical Solidification; Access Control; Monitored Natural Attenuation

Alternative 5: OAC 3745-27-11 Cap; Soil Chemical Stabilization; Access Control; Monitored Natural Attenuation

Alternative 6: Phytoremediation (Hydraulic Control and Treatment); Access Control; Monitored Natural Attenuation

The removal action alternatives are evaluated based on a variety of technical, environmental, human health, institutional, and cost factors. Table 8-2 shows the remedial alternative array with the alternatives' specific technology composition. The specific evaluation criteria are identified and discussed below.

Timeliness:

Timeliness refers to two aspects of risk mitigation and the program goals. First it refers to how quickly the alternative can be implemented (e.g., are materials readily available). Secondly, it refers to how quickly the implementation of the alternative will achieve the defined removal action objectives.

Protection of Human Health and The Environment:

The evaluation of each alternative with respect to protection of human health and the environment will be based on the degree to which the alternative 1) provides short- and long-term minimization of the potential for receptor exposure (through direct ingestion, dermal contact, and inhalation) to affected Site media, 2) is protective during implementation, 3) impacts adjoining property / affects the community and community reaction, and 4) addresses the effect of residuals.

Technical Feasibility:

Technical Feasibility refers to the extent to which each alternative can technically achieve the removal action objective based upon the current developmental status of the technologies. It will be evaluated based upon past performance at similar sites as indicated in the published literature and based upon standard engineering principles.

Major Institutional Considerations:

Major institutional considerations for each alternative will also be evaluated. The institutional concerns primarily fall within two areas. First, they address practical compliance with ARARs. Second, they address potential regulatory requirements in regards to permitting and timeliness of review.

Cost Analysis:

The cost analysis of the removal action alternatives involves estimation of the potential capital cost of implementing each alternative as well as the annual operating and maintenance (O&M) costs. The cost estimates are based on the Site investigations, ERM experience on similar projects, U.S. EPA's CORA cost model, and published cost estimating manuals. The estimates are not based on detailed design data and are therefore considered estimates for comparison purposes. Based upon the estimated capital and O&M costs, a present worth cost (assuming a 5% discount

rate) is estimated for each alternative. The cost estimates are included in Table 8-3 and a detailed cost breakdown is presented in Appendix P.

8.4.1

Alternative 1: Engineered Clay Cap; Selective Soil Physical Solidification; Access Control; Monitored Natural Attenuation

Under this alternative, an engineered multi-layer clay cap will be installed over the Consolidation Area. Figure 8-1 depicts the area where the cap will be constructed. Approximately 3.2 acres will be covered with the engineered clay cap. Figure 8-4 shows a typical cross section of the construction of an engineered clay cap.

Alternative 1 involves physical solidification of selected portions of the consolidated materials (approximately 10,000 cubic yards) as necessary to provide adequate support for construction of the cap. The physical solidification will be accomplished by mixing cement and hydrated lime with the consolidated material to attain the desired engineering properties.

Under this alternative, improved fencing and security will be provided to control access to the Site and to help ensure the long-term integrity of the cap.

Monitored Natural Attenuation will be conducted for three years to monitor site specific ground water and natural attenuation parameters (i.e., confirm natural attenuation is occurring and there are no significant changes in the ground water quality). After the first three years of performance monitoring, the analytical data will be evaluated to determine the frequency of and analytical parameters for additional monitoring. The details of the ground water monitoring program will be developed when the detailed design and operation and maintenance plans are prepared. In addition, one monitoring well will be installed east of monitoring well MW-13. A long-term (30-year) maintenance program also is assumed for Alternative 1.

Timeliness:

The materials and construction resources necessary to implement Alternative 1 are readily available. It is anticipated that the removal action construction could be accomplished in a full one-year time frame under normal weather conditions. During the remedial design phase, additional time would be required for field and bench testing the physical solidification process. Once the implementation is completed, the potential risk posed by the Site will be immediately mitigated.

Protection of Human Health and the Environment:

Alternative 1 will be highly effective in minimizing long-term exposure of human and ecological receptors to the constituents of concern in the consolidated material and impacted soil at the Site. The capping also will significantly reduce infiltration of precipitation, thus minimizing the possibility of constituents leaching out of the materials and migrating to ground water.

Potential short-term exposures for construction workers during implementation of Alternative 1 will be minimized by using conventional remediation health and safety procedures. Access and dust/vapor controls will protect the surrounding rural community during construction.

Technical Feasibility:

The technologies for engineered clay caps and physical solidification of soil are well-developed and have been used in many applications similar to the Greiner's Lagoon Site. The June 22, 2000 Treatability Testing Report for the Solidification of Soft Consistency Materials from the Greiner's Lagoon Site, Sandusky County, Ohio prepared by IT Technology Applications Laboratories provides the technical demonstration that the soft consistency materials can be solidified, resulting in a high compressive strength treated material. The treated material can easily support the proposed cap and have minimal impact to human health and the environment due to leaching. The Treatability Testing Report is provided in Appendix O.

With proper maintenance and monitoring, Alternative 1 will provide a high degree of long-term reliability.

Major Institutional Considerations:

Alternative 1 may necessitate obtaining an ARAR waiver since the engineered cap may not meet the substantive requirements. Other regulatory issues to be addressed during the remedial design phase include minimum acceptable performance standards for treatment including development of site-specific maximum SPLP concentrations. The regulatory review periods may not be routine for documents necessary to implement the alternative. With effective public information and the use of access and dust/vapor controls during construction, the surrounding community is not expected to have significant concerns about Alternative 1.

Cost Analysis:

The estimated capital, O&M, and present worth costs for Alternative 1 are presented in Table 8-3. For comparison to other alternatives, the estimated O&M cost assumes that Site maintenance will be performed over a 30-year period. As shown in Table 8-3, the estimated present worth cost for Alternative 1 is \$ 2.0 million.

8.4.2

Alternative 2: Engineered Clay Cap; Soil Chemical Stabilization; Access Control; Monitored Natural Attenuation

Alternative 2 involves chemically stabilizing the material in the Consolidation Area of the Site as shown on Figure 8-2. Chemical stabilization will be achieved by mixing the Site materials with a cement-based or pozzolanic material. As shown in Figure 8-2, an engineered clay cap will be installed over the chemically stabilized area of the Site. Approximately 3.2 acres will be covered with the engineered clay cap. Figure 8-4 shows a typical cross section of the cap.

This alternative will include fencing and security improvement to control access to the Site and to help ensure the long-term integrity of the engineered clay cap.

Monitored Natural Attenuation will be conducted for three years to monitor site specific ground water and natural attenuation parameters (i.e., confirm natural attenuation is occurring and there are no significant changes in the ground water quality). After the first three years of performance monitoring, the analytical data will be evaluated to determine the frequency of and analytical parameters for additional monitoring. The details of the ground water monitoring program will be developed when the detailed design and operation and maintenance plans are prepared. In addition, one monitoring well will be installed east of monitoring well MW-13. A long-term (30-year) maintenance program also is assumed for Alternative 2.

Timeliness:

The materials and construction resources necessary to implement Alternative 2 are readily available. It is anticipated that the removal action construction could be accomplished in a full one-year time frame under normal weather conditions. During the remedial design phase, additional time would be required for bench and field testing the chemical stabilization process. Once the implementation is completed, the potential risk posed by the Site will be immediately mitigated.

Protection of Human Health and the Environment:

Alternative 2 will be highly effective in minimizing long-term exposure of human and ecological receptors to the constituents of concern in the consolidated material and impacted soil at the Site. The capping also will significantly reduce infiltration of precipitation, thus minimizing the possibility of constituents leaching out of the treated materials and migrating to ground water. Moreover, chemical stabilization will further minimize the potential for the constituents of concern to leach out of the treated material.

Potential short-term exposures for construction workers and the surrounding community would be greatest under Alternative 2; however, this possibility can be minimized by using conventional health and safety procedures and employing access and dust/vapor controls during construction.

Technical Feasibility:

The technologies for engineered clay caps and chemical stabilization of materials are well-developed and have been used in many applications similar to the Greiner's Lagoon Site. With proper maintenance and monitoring, Alternative 2 will provide a high degree of long-term reliability.

Major Institutional Considerations:

Alternative 2 may necessitate obtaining an ARAR waiver since the engineered cap may not meet the substantive requirements. The regulatory review periods may not be routine for documents necessary to implement the alternative. With effective public information and the use of access and dust/vapor controls during construction, the surrounding community is not expected to have significant concerns about Alternative 2.

Cost Analysis:

The estimated capital, O&M, and present worth costs for Alternative 2 are presented in Table 8-3. For comparison to other alternatives, the estimated O&M cost assumes that Site maintenance will be performed over a 30-year period. As shown in Table 8-3, the estimated present worth cost for Alternative 2 is \$6.0 million.

Alternative 3: Excavation; Off-site Landfilling; Backfill with Clean Fill; Access Control

Alternative 3 entails excavation and off-site landfilling of the material in the Consolidation Area of the Site. Figure 8-3 shows the area of the Site that will be excavated. For the purposes of this evaluation, it has been assumed that half of the material excavated would be disposed of as non-hazardous solid waste and the remaining half would be disposed of as hazardous waste. The area of the site where the consolidated material and impacted soil is excavated and landfilled off-site will be backfilled with clean fill. This area will then be graded for proper drainage and seeded.

Alternative 3 will include fencing and security improvements to control access to the Site.

Timeliness:

The materials and construction resources necessary to implement Alternative 3 are readily available. It is anticipated that the removal action construction could be accomplished in a full one-year time frame under normal weather conditions. Once the implementation is completed, the potential risk posed by the Site will be immediately mitigated.

Protection of Human Health and the Environment:

Alternative 3 will be highly effective in minimizing long-term exposure of human and ecological receptors to the constituents of concern in the consolidated material and impacted soil at the Site. Under this alternative, the majority of the source of the constituents of concern will be removed from the Site.

Potential short-term exposures for construction workers during implementation of Alternative 3 will be minimized by using conventional remediation health and safety procedures. Access and dust/vapor controls will protect the surrounding community during on-site activities.

There is a potential risk to human health and the environment during off-site transportation. Off-site transportation, assuming accomplished feasibly during a 6 month period, will result in a daily average of approximately 70 one way trips (20 ton trucks; 5 days a week) over the roads of Sandusky County, some of which are not improved. Human health and the environment will be at risk during this time period due to potential dust emissions, noise, releases and accidents. Community reaction is not expected to be favorable for this reason and the perception that a large amount of fuel may be needlessly expended.

Technical Feasibility:

Excavation and off-site landfilling are commonly used to remediate materials such as those at the Site. There is adequate commercial landfill capacity available for this alternative. Alternative 3 will provide a high degree of long-term reliability.

Major Institutional Considerations:

Practical compliance with ARARs will be readily attained under Alternative 3. Routine regulatory reviews, approvals, and permits will be required under Alternative 3. With effective public information and the use of access and dust/vapor controls during construction, the surrounding community is not expected to have significant concerns about Alternative 3.

Cost Analysis:

The estimated capital, O&M, and present worth costs for Alternative 3 are presented in Table 8-3. As shown in Table 8-3, the estimated present worth cost for Alternative 3 is \$ 8.8 million.

8.4.4

Alternative 4: OAC 3745-27-11 Cap: Selective Soil Physical Solidification: Access Control; Monitored Natural Attenuation

Under this alternative, a cap constructed in accordance with OAC 3745-27-11 will be installed over the Consolidation Area. Figure 8-5 depicts the area where the cap will be constructed. Approximately 3.2 acres will be covered with the OAC 3745-27-11 cap. Figure 8-6 shows a typical cross section of the construction of the cap.

Alternative 4 involves physical solidification of selected portions of the consolidated materials (approximately 10,000 cubic yards) as necessary to provide adequate support for construction of the cap. The physical solidification will be accomplished by mixing cement and hydrated lime with the consolidated material to attain the desired engineering properties.

Under this alternative, improved fencing and security will be provided to control access to the Site and to help ensure the long-term integrity of the cap.

Monitored Natural Attenuation will be conducted for three years to monitor site specific ground water and natural attenuation parameters (i.e., confirm natural attenuation is occurring and there are no significant

changes in the ground water quality). After the first three years of performance monitoring, the analytical data will be evaluated to determine the frequency of and analytical parameters for additional monitoring. The details of the ground water monitoring program will be developed when the detailed design and operation and maintenance plans are prepared. In addition, one monitoring well will be installed east of monitoring well MW-13. A long-term (30-year) maintenance program also is assumed for Alternative 4.

Timeliness:

The material and construction resources necessary to implement Alternative 4 are readily available. It is anticipated that the removal action construction could be accomplished in a full-one-year time frame under normal weather conditions. During the remedial design phase additional time would be required for field and bench testing the solidification process. Once the implementation is completed, the potential risk posed by the Site will be immediately mitigated.

Protection of Human Health and the Environment:

Alternative 4 will be highly effective in minimizing long-term exposure of human and ecological receptors to the constituents of concern in the consolidated materials and impacted soil at the Site. The capping also will significantly reduce infiltration of precipitation, thus minimizing the possibility of constituents leaching out of the materials and migrating to ground water.

Using conventional remediation health and safety procedures will minimize potential short-term exposures for construction workers during implementation of Alternative 4. Access and dust/vapor controls will protect the surrounding rural community during construction.

Technical Feasibility:

The technologies for OAC 3745-27-11 caps and physical solidification of soil are well-developed and have been used in many applications similar to the Greiner's Lagoon Site. The June 22, 2000 Treatability Testing Report for the Solidification of Soft Consistency Materials from the Greiner's Lagoon Site, Sandusky County, Ohio prepared by IT Technology Applications Laboratories provides the technical demonstration that the soft consistency materials can be solidified, resulting in a low-permeability treated material. The treated material can easily support the proposed cap and have minimal impact to human health and the environment due to leaching. The Treatability Testing Report is provided in Appendix O.

With proper maintenance and monitoring, Alternative 4 will provide a high of long-term reliability.

Major Institutional Considerations:

Practical compliance with ARARs will be readily attainable for this alternative. Alternative 4 does not require any unusual regulatory approvals or permits. The regulatory review periods should be routine for documents necessary to implement the alternative. A regulatory issue to be addressed during the remedial design phase includes establishing minimum acceptable performance standards for treatment including development of site-specific maximum SPLP concentrations.

With effective public information and the use of access and dust/vapor controls during construction, the surrounding community is not expected to have significant concerns about Alternative 4.

Cost Analysis:

The estimated capital, O&M, and present worth costs for Alternative 4 are presented in Table 8-3. For comparison to other alternatives, the estimated O&M cost assumes that Site maintenance will be performed over a 30-year period. As shown in Table 8-3, the estimated present worth cost for Alternative 4 is \$2.4 million.

8.4.5

Alternative 5: OAC 4745-27-11 Cap: Soil Chemical Stabilization: Access Control; Monitored Natural Attenuation

Under this alternative, a cap constructed in accordance with OAC 3745-27-11 will be installed over the Consolidation Area. Figure 8-7 depicts the area where the cap will be constructed. Approximately 3.2 acres will be covered with the OAC 3745-27-11 cap. Figure 8-6 shows a typical cross section of the construction of the cap.

Alternative 5 involves chemically stabilizing the material in the Consolidation Area of the Site as shown on Figure 8-7. Chemical stabilization will be achieved by mixing the Site materials with a cement-based or pozzolanic material.

This alternative will include fencing and security improvement to control access to the Site and to help ensure the long-term integrity of the engineered clay cap.

Monitored Natural Attenuation will be conducted for three years to monitor site specific ground water and natural attenuation parameters

(i.e., confirm natural attenuation is occurring and there are no significant changes in the ground water quality). After the first three years of performance monitoring, the analytical data will be evaluated to determine the frequency of and analytical parameters for additional monitoring. The details of the ground water monitoring program will be developed when the detailed design and operation and maintenance plans are prepared. In addition, one monitoring well will be installed east of monitoring well MW-13. A long-term (30-year) maintenance program also is assumed for Alternative 5.

Timeliness:

The material and construction resources necessary to implement Alternative 5 are readily available. It is anticipated that the removal action construction could be accomplished in a full-one-year time frame under normal weather conditions. During the remedial design phase, additional time would be required for field and bench testing the chemical stabilization process. Once the implementation is completed, the potential risk posed by the Site will be immediately mitigated.

Protection of Human Health and the Environment:

Alternative 5 will be highly effective in minimizing long-term exposure of human and ecological receptors to the constituents of concern in the consolidated materials and impacted soil at the Site. The capping also will significantly reduce infiltration of precipitation, thus minimizing the possibility of constituents leaching out of the materials and migrating to ground water.

Using conventional remediation health and safety procedures will minimize potential short-term exposures for construction workers during implementation of Alternative 5. Access and dust/vapor controls will protect the surrounding rural community during construction.

Technical Feasibility:

The technologies for OAC 3745-27-11 caps and soil chemical stabilization of soil are well-developed and have been used in many applications similar to the Greiner's Lagoon Site. With proper maintenance and monitoring, Alternative 5 will provide a high of long-term reliability.

Major Institutional Considerations:

Practical compliance with ARARs will be readily attainable for this alternative. Alternative 5 does not require any unusual regulatory

approvals or permits. The regulatory review periods should be routine for documents necessary to implement the alternative. With effective public information and the use of access and dust/vapor controls during construction, the surrounding community is not expected to have significant concerns about Alternative 5.

Cost Analysis:

The estimated capital, O&M, and present worth costs for Alternative 5 are presented in Table 8-3. For comparison to other alternatives, the estimated O&M cost assumes that Site maintenance will be performed over a 30-year period. As shown in Table 8-3, the estimated present worth cost for Alternative 5 is \$6.5 million.

8.4.6 *Alternative 6: Phytoremediation (Hydraulic Control and Treatment); Access Control; Monitored Natural Attenuation*

Under this alternative, a phytoremediation system would be installed at the Consolidation Area. A Phytoremediation Feasibility Study was performed for the site and is included in Appendix M. A conceptual design of the phytoremediation technology is included in the study.

Under this alternative, improved fencing and security will be provided to control access to the Site and to help ensure the long-term integrity of the phytoremediation system.

Monitored Natural Attenuation will be conducted for three years to monitor site specific ground water and natural attenuation parameters (i.e., confirm natural attenuation is occurring and there are no significant changes in the ground water quality). After the first three years of performance monitoring, the analytical data will be evaluated to determine the frequency of and analytical parameters for additional monitoring. The details of the ground water monitoring program will be developed when the detailed design and operation and maintenance plans are prepared. In addition, one monitoring well will be installed east of monitoring well MW-13. A long-term (30-year) maintenance program also is assumed for Alternative 6.

Although this is a recognized innovative technology, monitoring to evaluate its effectiveness will be conducted during the first five years. If after five years, the monitoring shows that the technology is not effective, the alternative will be enhanced, supplemented or replaced.

Timeliness:

The material and construction resources necessary to implement Alternative 6 are readily available. It is anticipated that construction could be accomplished in a full-one-year time frame under normal weather conditions. Once the implementation is complete, the potential risk posed by the site will be immediately mitigated.

Alternative 6 is a recognized innovative technology whose benefits are ongoing. The tall grasses will grow rapidly throughout the spring and summer, and by the end of summer the Site will have a dense mat of tall grasses protecting the soil from erosion and contact. Additionally, the grasses will be transpiring water. The trees will become more of a factor the second and third year, reaching an ideal plant density. As the roots grow, the combined action of roots and microbes will facilitate the degradation of constituents and provide hydraulic control.

Protection of Human Health and the Environment:

Alternative 6 will be highly effective in minimizing long-term exposure of human and ecological receptors to the constituents of concern in the consolidated materials and impacted soil at the Site. The established vegetation will cover the soil and degrade constituents present. Transpiration will reduce the infiltration of precipitation, thus minimizing the possibility of constituents leaching out of the materials and migrating to ground water. The tree barrier will also minimize the migration of ground water. The risk will continue to be reduced throughout the life of the phytoremediation system.

Using conventional remediation health and safety procedures will minimize potential short-term exposures for construction workers during implementation of Alternative 6. Access and dust/vapor controls will protect the surrounding rural community during construction.

Technical Feasibility:

Phytoremediation is a recognized innovative technology. As seen in the Phytoremediation Feasibility Study (Appendix M), it is well suited for the Greiner's Lagoon Site. Although this is a recognized innovative technology, monitoring to evaluate its effectiveness will be conducted during the first five years. If after five years, the monitoring shows that the technology is not effective, the alternative will be enhanced, supplemented or replaced.

Major Institutional Considerations:

Practical compliance with the ARARs will be readily obtained under Alternative 6. Alternative 6 does not require any unusual regulatory approvals or permits. With effective public information on the potential restoration of the site to a natural ecosystem and the use of access and dust/vapor controls during construction, the surrounding community is not expected to have significant concerns about Alternative 6.

Cost Analysis:

The estimated capital, O&M, and present worth costs for Alternative 6 are presented in Table 8-3. For comparison to other alternatives, the estimated O&M cost assumes that Site maintenance will be performed over a 30-year period. As shown in Table 8-3, the estimated present worth cost for Alternative 6 is \$1.2 million.

8.5

IDENTIFICATION OF ARARS

Non-time critical removal actions are intended, to the extent practical, to attain or exceed the ARARs of the federal and Ohio EPA environmental and public health laws in consideration of the urgency of the situation and the scope of the removal action. The selection of ARARs is dependent on the hazardous substances present at a site, site characteristics, location and the specific remedial or removal actions under consideration. These requirements may be chemical-specific, location-specific, or action-specific. Chemical-specific ARARs are health- or risk-based concentration limits set for specific hazardous substances, pollutants, or contaminants. Location-specific ARARs are restrictions placed on the conduct of activities solely because they are in specific locations. Examples of such specific locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats. Action-specific ARARs control or restrict particular types of removal actions selected as alternatives for cleanup of a site.

Appendix Q represents the universe of federal and state statutes and regulations which are potential ARARs. A final list of ARARs cannot be set forth until the removal action alternatives is chosen and the final design is complete. Appendix Q provides the ARAR citation and defines the type of ARAR (chemical-specific, action-specific, or location-specific).

8.5.1

Chemical-specific ARARS

A total of 47 constituents (VOCs, SVOCs, Metals and Pesticides) of potential concern (COPC) were detected in soil, ground water surface water, or sediments at the site.

VOCs and SVOCs are the primary contaminants identified at the site. There is no applicable federal or state promulgated cleanup criteria for VOCs and SVOCs for soil. ARARs however do exist for PCBs. The maximum concentration observed at the Greiner Site was 38 mg/kg for PCB.

The U. S. Environmental Protection Agency (EPA) recently published its "new" final rule for the management of PCBs in the June 29, 1998 Federal Register. This rule establishes substantial statutory amendments under TSCA and provides statutory authority for policies that EPA has developed and implemented since the late 1970s.

The final rule states that sites with PCB waste concentrations less than or equal to 50 ppm placed, spilled, or released to the environment prior to April 18, 1978 are "presumed not to present an unreasonable risk of injury to health or the environment from exposure to PCBs." The new rule states that PCBs placed, spilled, or otherwise released to the environment after April 18, 1978 must be disposed in accordance with the existing PCB Spill Cleanup Policy. For low occupancy areas, PCB waste may remain at concentrations < 25 mg/kg without restriction, or at concentrations >25 mg/kg and < 50 mg/kg if fenced and marked with a sign, or at concentrations >25 mg/kg and < 100 mg/kg if capped and with deed restrictions.

Other chemical-specific ARARs applicable to the site include the maximum contaminant levels (MCLs) specified by the Safe Drinking Water Act and promulgated by Ohio EPA. The Clean Water Act also prohibits the discharge of any pollutants from any point source to navigable waters.

8.5.2

Location-specific ARARS

Location specific ARARs are restriction placed on the conduct of remedial activities solely because they are done at the Greiner's Lagoon Site. Typically these ARARs will address impacts to historic sites, sensitive ecosystems and habitats, and floodplain or wetland restrictions. U.S. EPA has identified the following location-specific requirements to be evaluated for potential ARARs:

- RCRA Location Requirements

- National Historic Preservation Act of 1966
- Endangered Species Act
- Wilderness Act
- Fish and Wildlife Coordination Act
- Wild and Scenic Rivers Act
- Coastal Zone Management Act
- Clean Water Act

Contacts with governmental agencies and the Site reconnaissance did not identify any federal threatened or endangered species at the Site that could be impacted by potential removal actions. A potential ARAR relating to wetland areas may however exist. As noted in Section 6.1.1.3, several potential wetland areas occur on, or directly adjacent to the Greiner's Lagoon Site

8.5.3 *Action-specific ARARs*

The action specific ARARs are usually technology or activity based requirements or limitations and are triggered by the selection of a particular remedy.

Ohio EPA OAC 3745-27-11, Final Closure of Sanitary Landfill Facilities, is a potential ARAR. The code applies to the closure of existing sanitary landfills, but certain provision for cover systems are relevant and appropriate. The code specifies construction of a cap system during closure to minimize infiltration. The following components of the cap are required by OAC 3745-27-11:

- A recompact soil barrier layer, minimum of 2 feet thick, constructed in accordance with OAC 3745-27-08.
- A granular drainage layer, minimum 1-foot thick, on top of the soil barrier layer, constructed in accordance with OAC 3745-27-08.
- A vegetative layer consisting of soil and vegetation placed on top of the granular drainage layer.

The code allows for "comparable material and/or thickness for the soil barrier layer, granular drainage layer, and soil vegetative layer" if approved by the Ohio Director of Solid Waste. This provision in the code for an alternate design was used to develop the proposed remedial alternatives for Greiner's Lagoon Site.

Capping is a removal action under Alternatives 1 2, 4, and 5 at the Greiner's Lagoon Site. Potential ARARs for caps include:

- Provide long-term minimization of liquid migration through the capped area (40 CFR 264.310(a));
- Function with minimum maintenance (40 CFR 264.310(a));
- Promote drainage and minimize erosion or abrasion of the cover (40 CFR 264.320(a));
- Accommodate settling and subsidence so that the cover's integrity is maintained (40 CFR 264.310(a));
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoil's present (40 CFR 264.310(a));
- Restrict post-closure use of property as necessary to prevent damage to the cover (40 CFR 264.117(c));
- Prevent run-on and run-off from damaging cover (40 CFR 264.228(b) and 40 CFR 264.310(b)).

Ohio EPA has parallel cap requirements under OAC 3745. Alternative 6-Phytoremediation (Hydraulic Control and Treatment) is not only a cover but also a treatment. In order for phytoremediation to function as a treatment, a controlled amount of infiltration is necessary and high impermeability is not desirable. Except for ARARs that would prevent controlled infiltration, all other ARARs pertinent to caps are likewise pertinent to a phytoremediation-based cover.

Excavation and off-site disposal of the consolidated materials and impacted soil is a removal action under Alternative 3 for the Site. Potential ARARs for excavation and off-site disposal include:

- Determine if the material is non-hazardous or hazardous (40 CFR 262.11);
- Off-site, non-hazardous solid waste land disposal facilities must meet minimum technology requirements (40 CFR 241);
- Materials containing RCRA hazardous wastes subject to land disposal restrictions (40 CFR 268);
- Transportation of hazardous waste off site (40 CFR 363, 49 CFR 178-180);
- Land disposal of hazardous waste must be in facilities that meet minimum technology requirements (40CFR 264.301).

Ohio EPA has parallel requirements for excavation and off-site disposal of materials under OAC 3745.

On-site treatment of the consolidated materials and impacted soil is a removal action under Alternatives 1 2, 4, 5 and 6 for the Greiner's Lagoon Site. Potential ARARs for on-site treatment include:

- Treatment of hazardous waste in tanks, piles, or miscellaneous units (40 CFR 264 Subparts J, L, X);
- Control of air emissions from the treatment unit (40 CFR 52 Subpart KK);
- Issuance of Ohio EPA Permit to Install (PTI) prior to installation or construction of equipment that may be a source of air pollution (OAC 3745-31);
- Issuance of Ohio EPA Permit to Operate after conditions in PTI have been met (OAC 3745-35).

Under OAC 3745, Ohio EPA has requirements parallel to U.S. EPA's requirements for treatment of hazardous waste in tanks, piles, or miscellaneous units.

Other regulations that may be applicable for capping, excavation/off-site disposal, or on-site treatment at the Site are Ohio EPA's OAC 3745-15-07, OAC 3745-17-08, and OAC 3745-38. OAC 3745-15-07 restricts air pollution nuisances such as dust, dirt, vapors, and odors. OAC 3745-17-08 restricts the emission of fugitive dust from site operations. Under OAC 3745-38, a storm water permit may be required for construction activities at the Site.

9.0 **COMPARISON OF ALTERNATIVES AND SELECTION OF RECOMMENDED REMOVAL ACTION**

9.1 **COMPARISON OF ALTERNATIVES**

This section of the EE/CA Report provides a comparison of the removal action alternatives in light of the evaluation criteria, and highlights their relative advantages and disadvantages. Table 9-1 presents a summary of the comparison of the six removal action alternatives relative to the screening criteria described below.

9.1.1 ***Timeliness***

All six of the alternatives use construction labor, equipment, and materials that are readily available, and construction methods that are well understood. Under Alternatives 1, 2, 4, 5 and 6, the remedial design phase would include bench and field testing. Once construction is started, it is expected to be completed within one full year under any of the alternatives, if weather conditions are normal.

Alternative 6 is a recognized innovative technology whose benefits are ongoing. The tall grasses will grow rapidly in the first year and protect the soil from erosion and contact, and begin transpiring water. The trees will become more of a factor the second and third year, reaching an ideal plant density.

9.1.2 ***Protection of Human Health and the Environment***

Each of the removal action alternatives will be effective in minimizing long-term exposure of human and ecological receptors to the constituents of concern in the consolidated material and impacted soil at the Site. Alternative 3 will result in the removal of the majority of the source of the constituents of concern, but it does pose some risk of releases during transportation of the materials to the disposal facility.

Potential short-term exposures for on-site construction workers would be greatest under Alternatives 2 and 5. However, using conventional health and safety procedures and employing access and dust/vapor controls during construction can minimize this possibility.

Under Alternative 3, there is a potential risk to human health and the environment during off-site transportation. Off-site transportation,

assuming accomplished feasibly during a 6 month period, will result in a daily average of approximately 70 one way trips (20 ton trucks; 5 days a week) over the roads of Sandusky County, some of which are not improved. Human health and the environment will be at risk during this time period due to potential dust emissions, noise, releases and accidents. Community reaction is not expected to be favorable for this reason and the perception that a large amount of fuel may be needlessly expended.

9.1.3 *Technical Feasibility*

The technologies for Alternatives 1 to 5 are well developed and have been widely used in many situations similar to the Greiner's Lagoon Site. See Appendix N: Case Studies - Solidification/Stabilization of Oily Materials for information regarding past experiences with solidification and stabilization of oily materials.

Alternative 6 is a recognized innovative technology. It is well suited for the Greiner's Lagoon Site. A Phytoremediation Feasibility Study is included in Appendix M. Although this is a recognized innovative technology, monitoring to evaluate its effectiveness will be conducted during the first five years. If after five years, the monitoring shows that the technology is not effective, the alternative will be enhanced, supplemented or replaced.

If proper maintenance and monitoring are provided, any of the alternatives will provide long-term reliability.

9.1.4 *Major Institutional Considerations*

Alternatives 1 and 2 may require a variance to ARAR provisions. The other four alternatives will not require unusual regulatory approvals or permits, and regulatory review periods should be of normal duration. With effective public information and the effective use of access and dust/vapor controls, the surrounding community is not expected to have significant concerns about any of the alternatives.

All of the alternatives would require institutional controls to prevent current and future owners of the property from implementing any activities that would negatively impact the site.

9.1.5 *Cost Analysis*

The evaluation of the removal action alternatives determined that all six alternatives are technically feasible, would be effective in protecting human health and the environment, and can be constructed within one

calendar year. The estimated present worth cost of the various Alternatives ranges from \$1.2 to \$8.8 million. The estimated present worth costs are:

- Alternative 1: Engineered Clay Cap; Selective Soil Physical Solidification; Access Control; Monitored Natural Attenuation; \$2.0 million.
- Alternative 2: Engineered Clay Cap; Soil Chemical Stabilization; Access Control; Monitored Natural Attenuation ; \$6.0 million.
- Alternative 3: Excavation; Off-site Landfilling; Access Control; \$8.8 million.
- Alternative 4: OAC 3745-27-11 Cap, Selective Soil Physical Solidification; Access Control; Monitored Natural Attenuation; \$2.4 million.
- Alternative 5: OAC 3745-27-11 Cap, Soil Chemical Stabilization; Access Control; Monitored Natural Attenuation; \$6.5 million.
- Alternative 6: Phytoremediation (Hydraulic Control and Treatment); Access Control; Monitored Natural Attenuation; \$1.2 million.

9.2

RECOMMENDED REMOVAL ACTION

Based on the evaluation and comparison of the removal action alternatives (as indicated above and in Table 9-1), either Alternative 6: Phytoremediation (Hydraulic Control and Treatment); Access Control, and Monitored Natural Attenuation or Alternative 4: OAC 3745-27-11 Cap, Selective Soil Physical Solidification; Access Control and Monitored Natural Attenuation is the recommended removal action. The remedies: (1) will achieve the removal action objective for the Site (i.e., eliminates the small potential risk to future construction workers from exposure to consolidated materials and impacted soil, and hypothetical ecological receptors from storm water run-off), (2) can be readily implemented and maintained, (3) controls infiltration of water into consolidated materials, thus minimizing the possibility of constituents leaching out of materials and migrating to ground water, (4) reduces the mobility/toxicity/concentrations of constituents in the media of concern, and (5) have costs on the lower end of the cost range.

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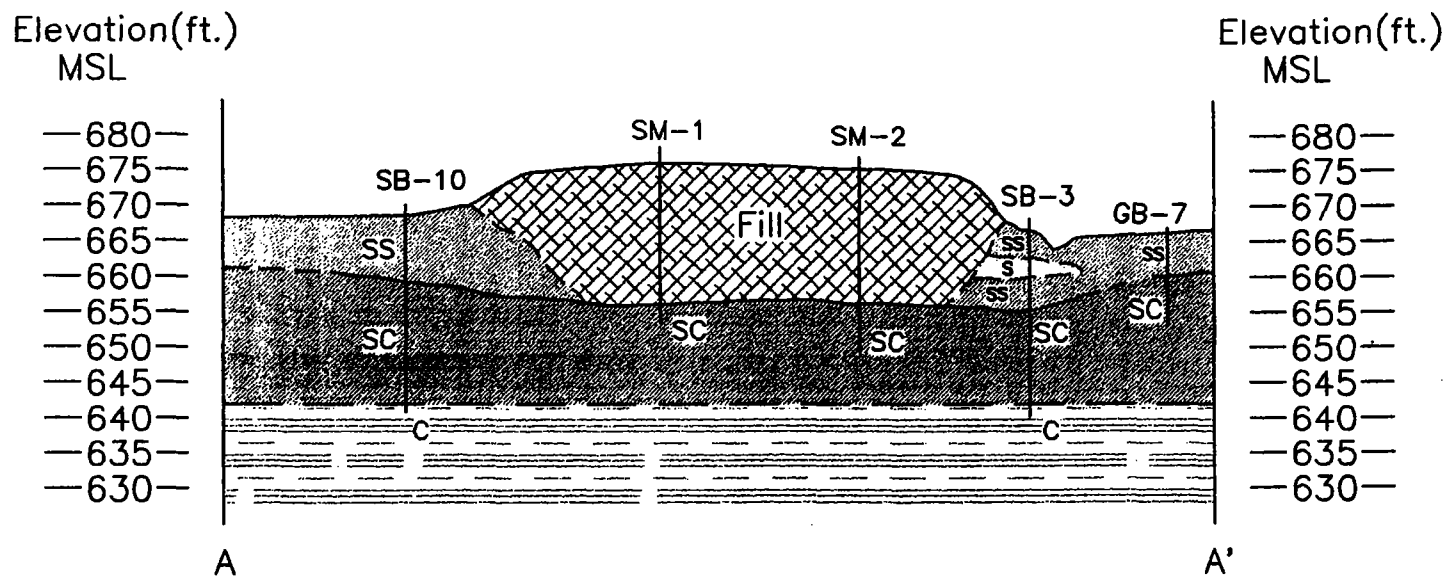
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Figures



ERM-Midwest, inc.

1-000-25



Legend

S = Sand
 SS = Silty Sand/Sandy Silt
 SC = Silty Clay
 C = Clay

NOTE: Stratigraphic Contacts dashed where inferred.

EE/CA SITE INVESTIGATION
GREINER'S LAGOON SITE
FREMONT, OHIO



ERM, Inc.
Environmental Resources Management
Columbus, Ohio

CROSS-SECTION A-A'

Scale : 1" = 80'

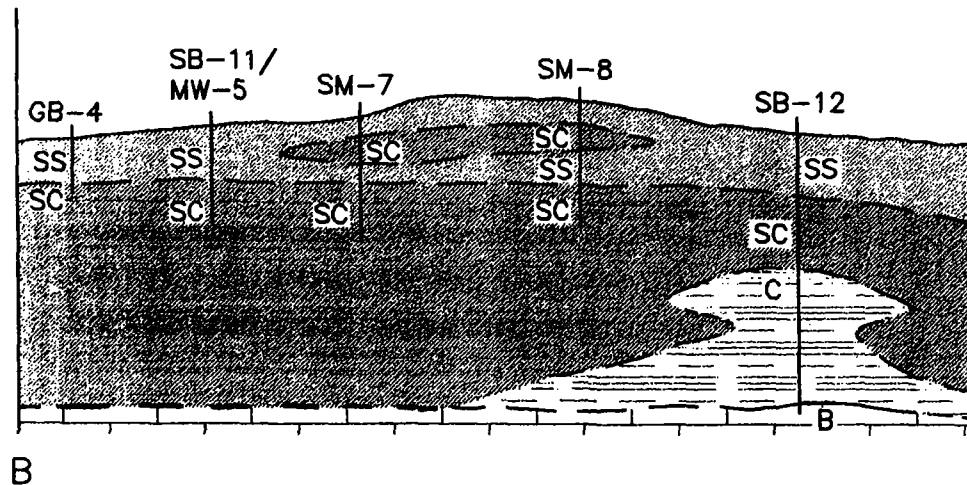
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Sheet : FIGURE 3-1

Elevation(ft.)
MSL

—680—
—675—
—670—
—665—
—660—
—655—
—650—
—645—
—640—
—635—
—630—



Elevation(ft.)
MSL

—680—
—675—
—670—
—665—
—660—
—655—
—650—
—645—
—640—
—635—
—630—

Legend

- S = Sand
- SS = Silty Sand/Sandy Silt
- SC = Silty Clay
- C = Clay
- B = Bedrock

NOTE: Stratigraphic Contacts dashed where inferred.

EE/CA SITE INVESTIGATION
GREINER'S LAGOON SITE
FREMONT, OHIO



ERM, Inc.
Environmental Resources Management
Columbus, Ohio

CROSS-SECTION B-B'

Scale : 1" = 60'

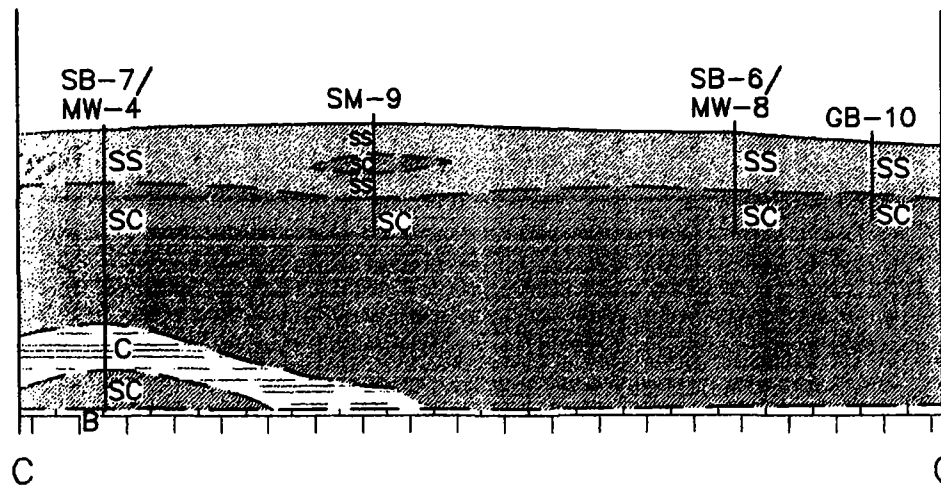
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Sheet : FIGURE 3-2

Elevation(ft.)
MSL

—680—
—675—
—670—
—665—
—660—
—655—
—650—
—645—
—640—
—635—
—630—



Elevation(ft.)
MSL

—680—
—675—
—670—
—665—
—660—
—655—
—650—
—645—
—640—
—635—
—630—

Legend

- S = Sand
- SS = Silty Sand/Sandy Silt
- SC = Silty Clay
- C = Clay
- B = Bedrock

NOTE: Stratigraphic Contacts dashed where inferred.

EE/CA SITE INVESTIGATION
GREINER'S LAGOON SITE
FREMONT, OHIO



BRM, Inc.
Environmental Resources Management
Columbus, Ohio

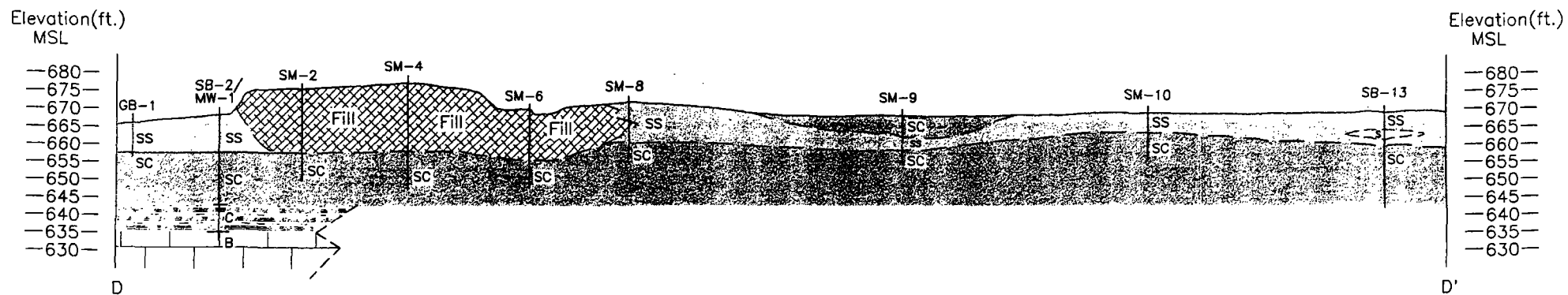
CROSS-SECTION C-C'

Scale : 1" = 90'

DATE : OCTOBER 1997

Dwg. No. :

Sheet : FIGURE 3-3



Legend

- S = Sand
- SS = Silty Sand/Sandy Silt
- SC = Silty Clay
- C = Clay
- B = Bedrock

NOTE: Stratigraphic Contacts dashed where inferred.

EE/CA SITE INVESTIGATION
GREINER'S LAGOON SITE
FREMONT, OHIO



ERM, inc.
Environmental Resources Management
Columbus, Ohio

CROSS-SECTION D-D'

Scale : 1" = 90'

DATE : OCTOBER 1997

Dwg. No. :

Sheet : FIGURE 3-4

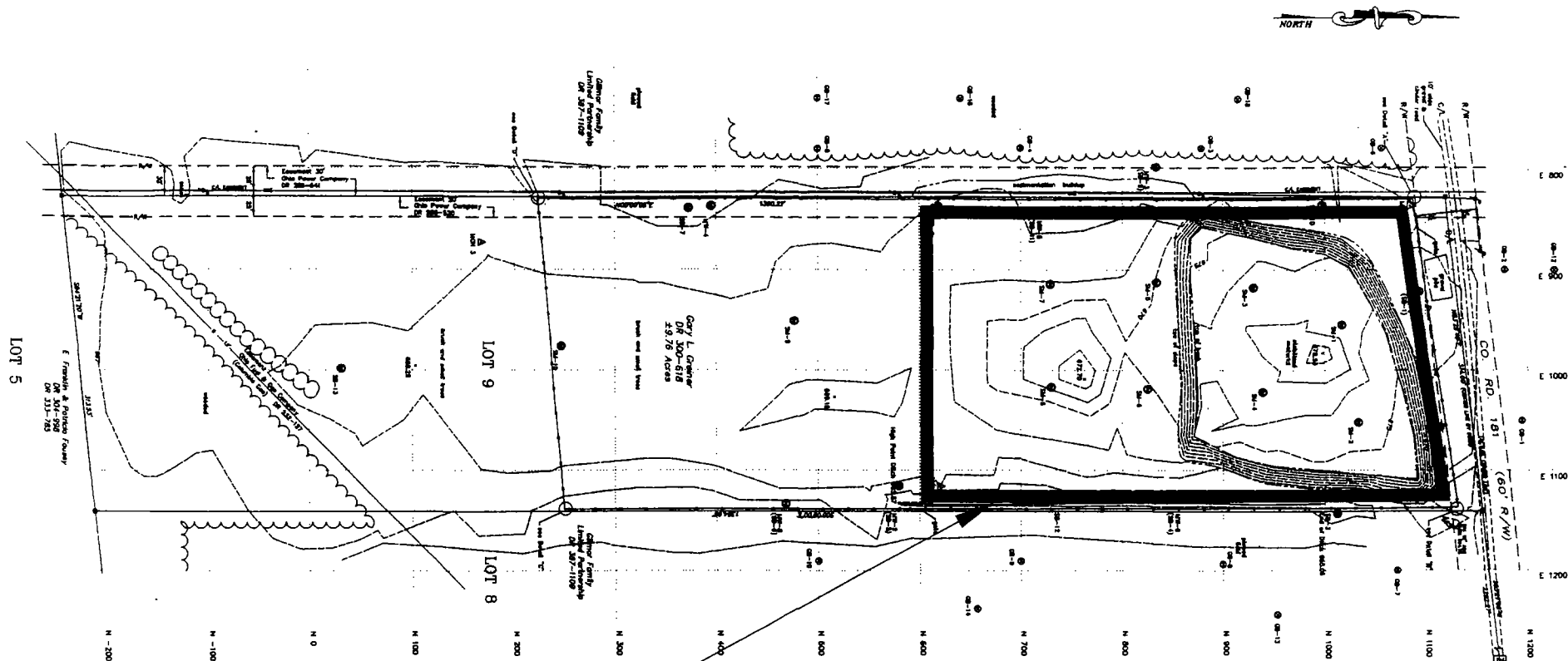
Figure 6-1
Habitat Covertypes Map
Greiner's Lagoon Site
Fremont, Ohio

Legend

- Property Line
- Fence
- Surface Water Flow Direction
- Monitoring Well Location
- Soil Boring Location
- Stabilized Material Boring Location
- Stressed Vegetation and Bare Areas
- Wooded Area A - Mixed Deciduous
- Wooded Area B - Mixed Deciduous
- Brush and Small Trees
- Wet Willow Area
- Marsh Area
- Ditch
- Drainage

Scale in Feet

0 60 120



ALTERNATIVE 1

- ENGINEERED CLAY CAP
- SELECTIVE IN-SITU SOIL SOLIDIFICATION
- SURFACE WATER CONTROLS
- GROUND WATER MONITORING
- SITE ACCESS RESTRICTIONS

EE/CA SITE INVESTIGATION
GREINER'S LAGOON SITE
FREMONT, OHIO



ERM

Environmental Resources Management

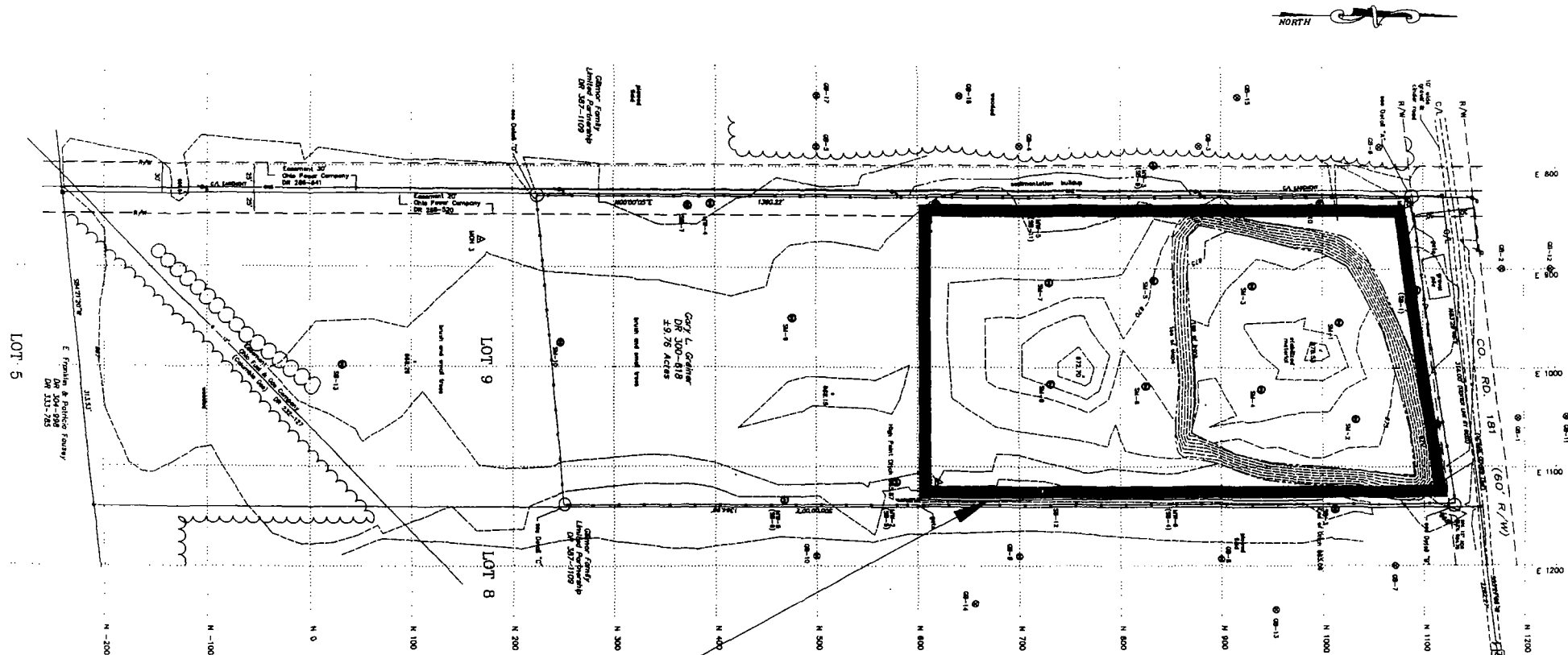
ALTERNATIVE 1

Scale: 1" = 100'

Date: OCTOBER 1997

Dwg. No.:

Sheet: FIGURE B-4



ALTERNATIVE 3

- EXCAVATE AND LOAD SOILS
- TRANSPORT TO DISPOSAL FACILITY
- DISPOSAL AT RCRA LANDFILL
- DISPOSAL AT SOLID WASTE LANDFILL
- BACKFILL WITH CLEAN FILL
- SITE ACCESS RESTRICTIONS

EE/CA SITE INVESTIGATION
GREINER'S LAGOON SITE
FREMONT, OHIO



ERM

Environmental Resources Management

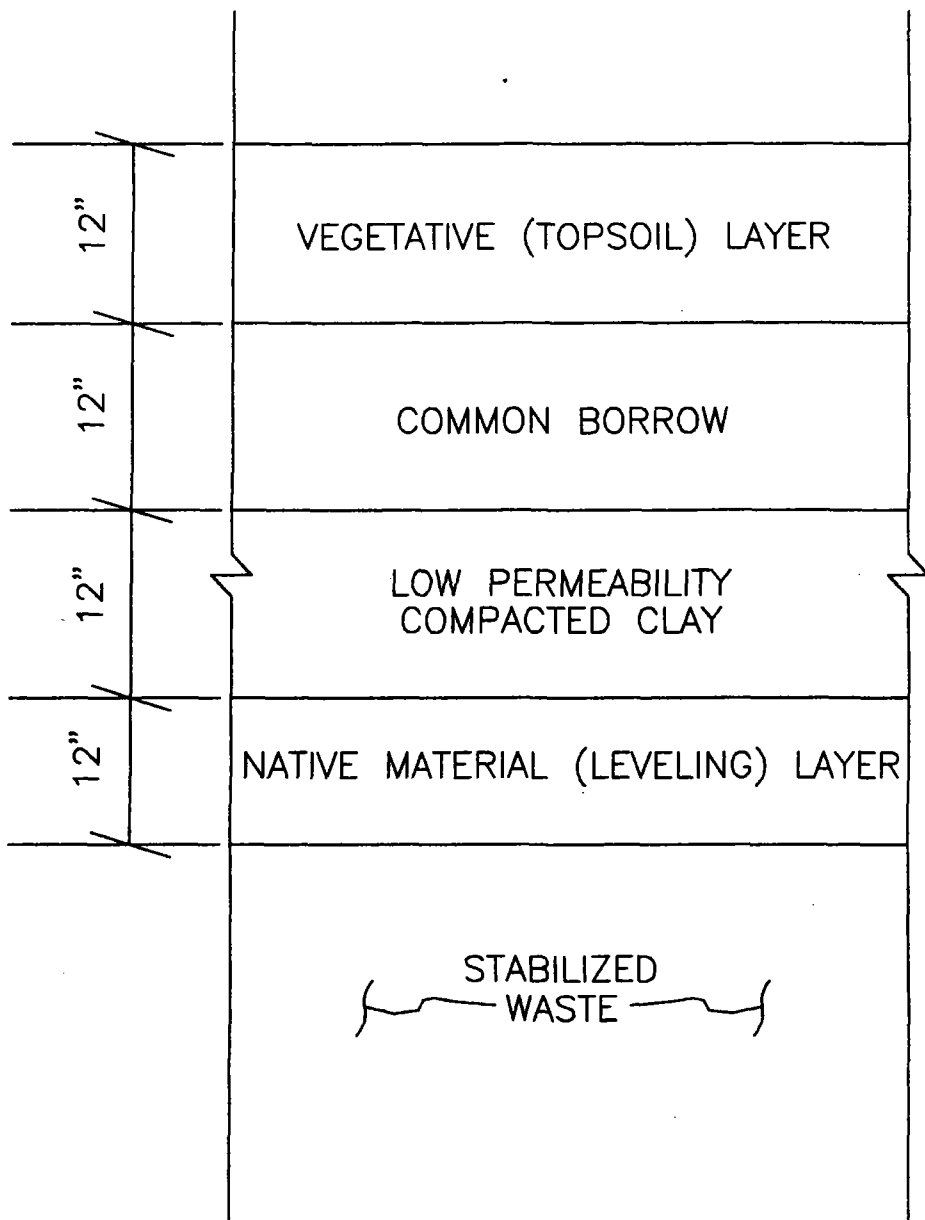
ALTERNATIVE 3

Scale : 1" = 100'

Date : OCTOBER 1997

Dwg. No.:

Sheet : FIGURE 8-3



EE/CA SITE INVESTIGATION
GREINER'S LAGOON SITE
FREMONT, OHIO

ENGINEERED CLAY CAP



ERM

ERM

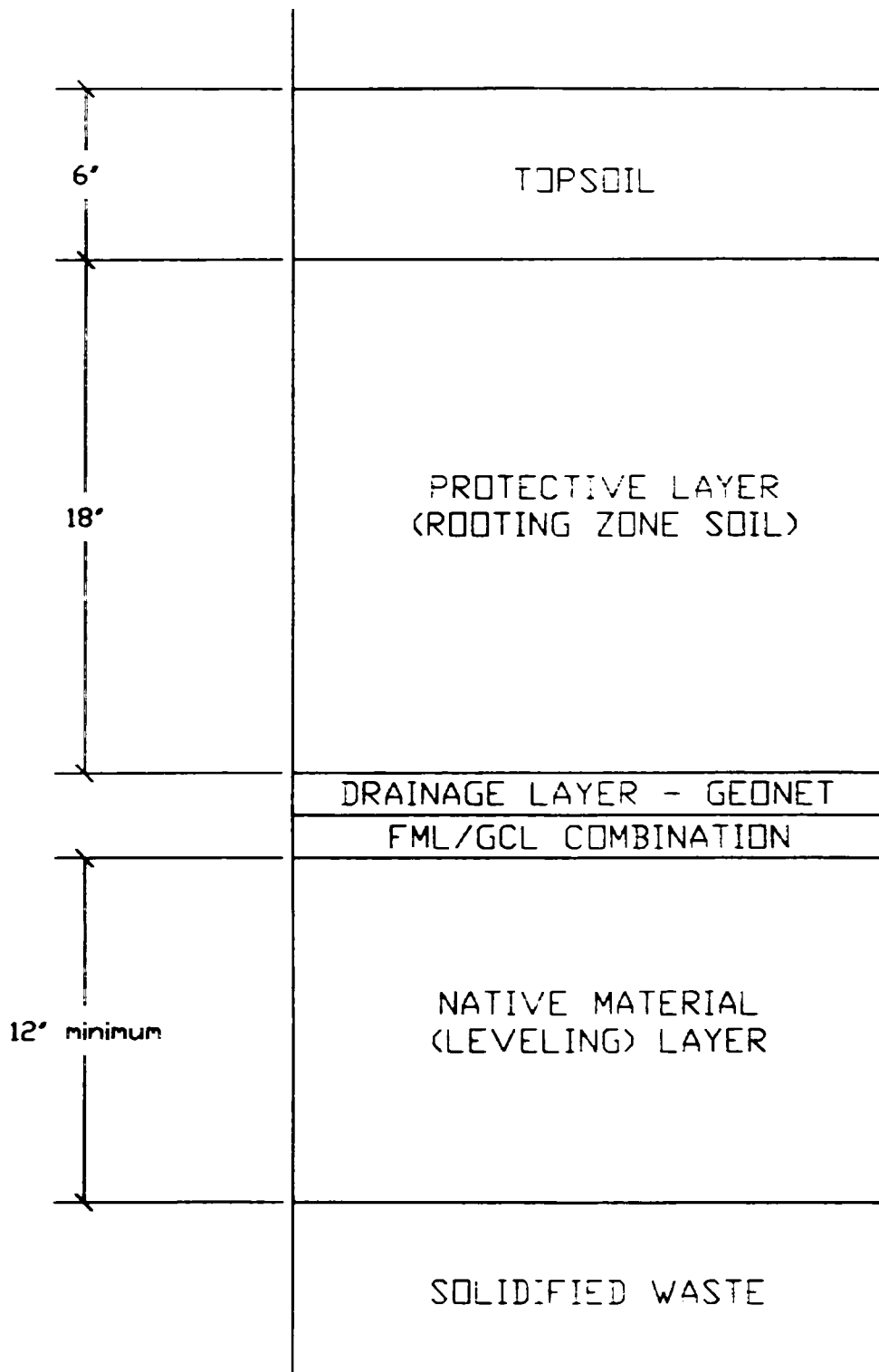
Environmental Resources Management

Scale : NONE

Date : OCTOBER 1997

Dwg. No.:

Sheet : FIGURE 8-4



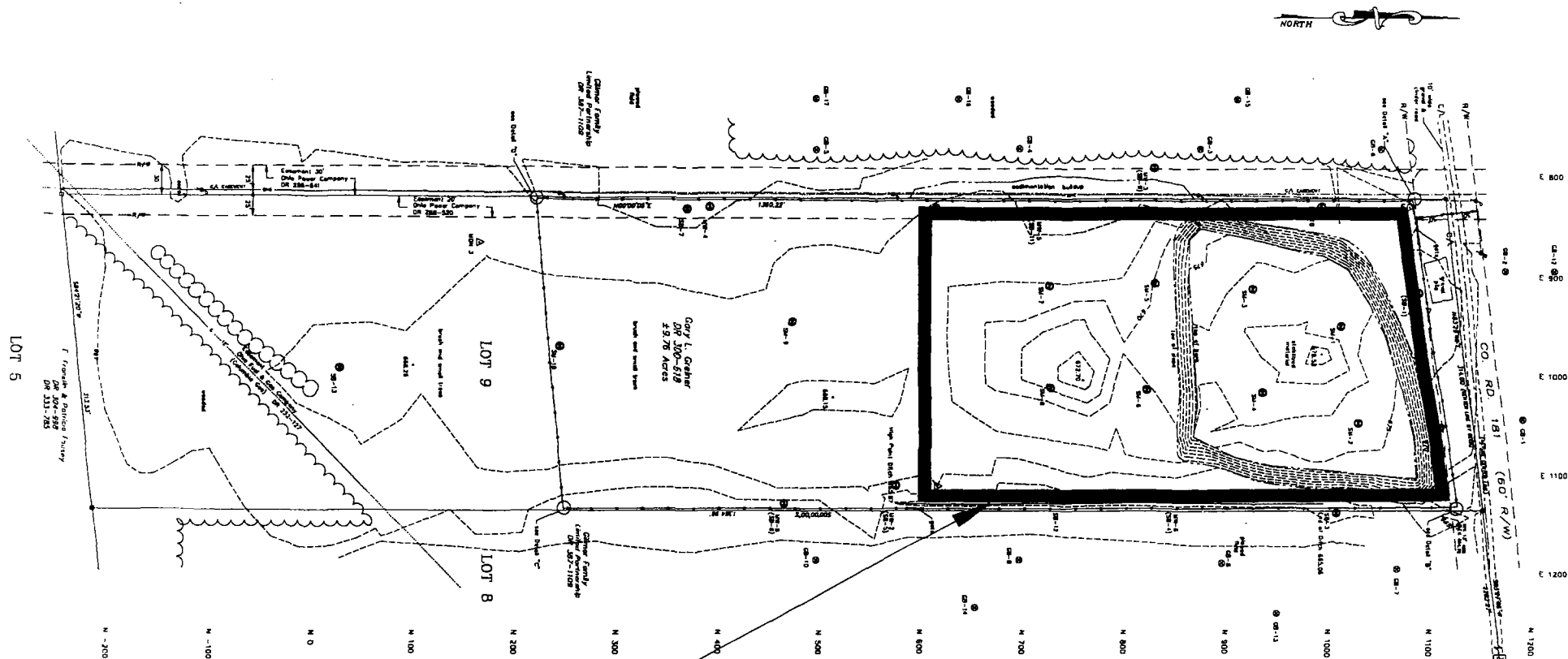
29 Sept. 1999

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Figure 8-6
DEPA CAP
(DAC 3745-27-11)



EE/CA Site
Investigation
Greiner's Lagoon Site
Fremont, Ohio



- ALTERNATIVE 5
- OHIO EPA CAP (OAC 3745-27-11)
 - IN-SITU SOIL (CHEMICAL) STABILIZATION
 - SURFACE WATER CONTROLS
 - GROUND WATER MONITORING
 - SITE ACCESS RESTRICTIONS

EE/CA SITE INVESTIGATION GREINER'S LAGOON SITE FREMONT, OHIO		ALTERNATIVE 5	
 ERM Environmental Resources Management	Scale : 1" = 100'		Date : AUGUST 2000
	Dwg. No.:		Sheet : FIGURE 8-7

Tables

TABLE 3-1
GROUND WATER ELEVATION DATA
GREINER'S LAGOON SITE
7/96 DATA

WELL	TOP OF CASING ELEVATION, FT. AMSL	DEPTH TO WATER (FT.)	GROUND WATER ELEVATION, FT. AMSL
MW-1 DEEP	668.13	19.66	648.47
MW-2 DEEP	669.88	21.14	648.74
MW-3 DEEP	669.22	20.47	648.75
MW-4	667.51	3.75	663.76
MW-5	668.56	4.69	663.87
MW-6	667.45	3.42	664.03
MW-7	668.09	4.45	663.64
MW-8	667.17	3.31	663.86

TABLE 3-2
GROUND WATER ELEVATION DATA
GREINER'S LAGOON SITE
11/10/98 DATA

WELL	TOP OF CASING ELEVATION, FT. AMSL	DEPTH TO WATER (FT.)	GROUND WATER ELEVATION, FT. AMSL
MW-1 DEEP	668.13	19.29	648.84
MW-2 DEEP	669.88	20.88	649.00
MW-3 DEEP	669.22	20.31	648.91
MW-4	667.51	7.29	660.22
MW-5	668.56	6.37	662.19
MW-6	667.45	4.38	663.07
MW-7	668.09	5.60	662.49
MW-8	667.17	4.73	662.44
MW-9	669.13	6.84	662.29
MW-10	670.82	10.23	660.59
MW-11	669.45	9.78	659.67
MW-12	669.89	11.88	658.01
MW-13	669.80	6.99	662.81
MW-14	669.70	6.78	662.92

TABLE 3-3
GROUND WATER ELEVATION DATA
GREINER'S LAGOON SITE
1/27/99 DATA

WELL	TOP OF CASING ELEVATION, FT. AMSL	DEPTH TO WATER (FT.)	GROUND WATER ELEVATION, FT. AMSL
MW-1 DEEP	668.13	18.27	649.86
MW-2 DEEP	669.88	20.02	649.86
MW-3 DEEP	669.22	19.34	649.88
MW-4	667.51	2.17	665.34
MW-5	668.56	4.05	664.51
MW-6	667.45	1.26	666.19
MW-7	668.09	2.72	665.37
MW-8	667.17	0.83	666.34
MW-9	669.13	4.90	664.23
MW-10	670.82	7.62	663.2
MW-11	669.45	8.77	660.68
MW-12	669.89	10.80	659.09
MW-13	669.80	3.61	666.19
MW-14	669.70	3.55	666.15

TABLE 3-4
GROUND WATER ELEVATION DATA
GREINER'S LAGOON SITE
4/28/99 DATA

WELL	TOP OF CASING ELEVATION, FT. AMSL	DEPTH TO WATER (FT.)	GROUND WATER ELEVATION, FT. AMSL
MW-1 DEEP	668.13	16.55	651.58
MW-2 DEEP	669.88	18.30	651.58
MW-3 DEEP	669.22	17.60	651.62
MW-4	667.51	1.50	666.01
MW-5	668.56	2.44	666.12
MW-6	667.45	0.92	666.53
MW-7	668.09	2.65	665.44
MW-8	667.17	0.72	666.45
MW-9	669.13	5.90	663.23
MW-10	670.82	3.75	667.07
MW-11	669.45	3.60	665.85
MW-12	669.89	3.60	666.29
MW-13	669.80	4.48	665.32
MW-14	669.70	4.31	665.39

Table 3-5
Hydraulic Conductivity Testing
 Lubrizol Corporation
 Fremont, Ohio

Well	Hydraulic Conductivity				Well Average Hydraulic Conductivity (ft/d)	Depth of Water in Well (ft)	Estimated Average Transmissivity* (ft ² /d)	Estimated Yield (Q)** (gpm)
	Range Slug-in (ft/d)	Range Slug-in (ft/d)	Range Slug-out (ft/d)	Range Slug-out (ft/d)				
MW-05	1.27	4.07	1.61	3.27	2.56	10.28	26.27	0.504
MW-06	0.51	-	0.45	0.65	0.537	12.93	6.94	0.167
MW-07	2.96	4.71	3.00	3.57	3.56	11.57	41.19	0.889
MW-08	4.61	5.52	5.76	5.80	5.42	13.26	71.90	1.78
MW-09	3.35	5.03	2.85	3.98	3.80	11.71	44.53	0.973
MW-10	0.07	-	NA	-	0.070	8.53	0.60	0.010
MW-11	0.32	-	0.23	-	0.275	7.57	2.08	0.029
MW-13	3.36	4.66	3.76	3.78	3.89	12.99	50.53	1.22
Average					2.51		30.50	

Note: Reference: Bouwer, H and Rice, R.C., 1976: A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells: Water Res. Res. V.12. No. 3

*- Transmissivity calculated from hydraulic conductivity and saturated aquifer thickness $T = Kb$

* *- Yield calculated from $Q = 0.5 \cdot H \cdot T / 2000$

After Driscoll 1986, Ground Water and Wells, St Paul, Minn

Table 3-6
VOC Migration Rate Calculation
 Lubrizol Corporation
 Fremont, Ohio

Ground Water Velocity* (ft/day)	Carbon Content Sample	Carbon Content foc (gm/gm)	VOC Koc** (ml/gm)	Soil-Water Partitioning Coeff kd (ml/gm)	Estimated Aquifer Bulk Density† (gm/cc)	Estimated Aquifer Porosity (gm/cc)	VOC† Velocity (ft/day)	VOC Velocity (ft/year)
0.0838	MW-11 (10-12')	0.0070	2.2	0.0154	1.85	0.3	0.0765	27.9337
0.0838	MW-12 (4-6')	0.0054	2.2	0.0119	1.85	0.3	0.0781	28.4987
0.0838	MW-13 (8-10')	0.0068	2.2	0.0150	1.85	0.3	0.0767	28.0031
Average:							0.0771	28.1452

Note: * - Ground water velocity (v) calculated from average hydraulic conductivity (K), porosity (e), and ground water gradient (g) by $v=Kge$

** - Koc value for Acetone - a low Koc site related compound. Reference: LaGreaga et.al., 1994, Hazardous Wastre Management, McGraw-Hill, Inc., NY, NY

† - Bulk density calculated from the density of the sediment minus the density of the water
 by: (sediment density) x (1-porosity) = aquifer bulk density : $(2.65) \times (1-0.3) = 1.85$

‡ - Reference: Freeze and Cherry, 1979, Groundwater, Prentice Hall

Table 4-1

Quantitation Limits for Inorganic and General Chemical Analyses

Parameter	Method	Quantitation Limit (QL) ⁽¹⁾		
		Water (mg/l)	Solid (mg/kg)	TCLP (mg/L)
Total Metals/TCLP Metals				
Arsenic	7060/6010	0.010	1.0	0.5
Barium	6010	0.20	20	10
Cadmium	6010	0.002	0.2	0.1
Chromium	6010	0.005	0.5	0.5
Cobalt	6010	0.05	5	0.05
Lead	6010	0.003	0.3	0.5
Mercury	7470/7471	0.0002	0.1	0.002
Nickel	6010	0.04	4	0.04
Selenium	7740/6010	0.005	0.5	0.25
Silver	6010	0.005	0.5	0.5

(1) Specific quantitation limits (QL) are highly matrix dependent. The detection limits listed here are not always achievable. QLs listed for solids are based on wet weight. The QLs calculated by the laboratory for solids, calculated on dry weight basis, are higher.

Table 4-1

Quantitation Limits for Organic Chemical Analyses

	Quantitation Limits ^(a)	
	Water (ug/L)	Low Solids ^(b) (ug/kg)
Volatile Organics Method 8240		
Chloromethane	10	10
Bromomethane	10	10
Vinyl chloride	10	10
Chloroethane	10	10
Methylene chloride	5	5
Acetone	20	20
Carbon disulfide	5	5
1,1-Dichloroethane	5	5
1,1-Dichloroethene	5	5
1,2-Dichloroethene (total)	5	5
Chloroform	5	5
1,2-Dichloroethane	5	5
2-Butanone	20	20
1,1,1-Trichloroethane	5	5
Carbon tetrachloride	5	5
Vinyl acetate	5	5
Bromodichloromethane	5	5
1,1,2,2-Tetrachloroethane	5	5
1,2-Dichloropropane	5	5
cis-1,3-Dichloropropene	5	5
Trichloroethene	5	5
Dibromochloromethane	5	5
1,1,2-Trichloroethane	5	5
Benzene	5	5
trans-1,3-Dichloropropene	5	5
Bromoform	5	5
2-Hexanone	20	20
4-Methyl-2-pentanone	20	20
Tetrachloroethene	5	5
Toluene	5	5
Chlorobenzene	5	5
Ethyl benzene	5	5
Styrene	5	5
Xylenes (total)	5	5

- Specific quantitation limits are highly matrix dependent. The limits listed herein are provided for guidance and are not always achievable.
- Quantitation limits listed for solids are based on wet weight. The quantitation limits calculated by the laboratory for solids, calculated on dry weight basis, are higher.

Table 4-1

Quantitation Limits for Organic Chemical Analyses

	Quantitation Limits ^(a)	
	Water ($\mu\text{g/L}$)	Low Solids ^(b) ($\mu\text{g/kg}$)
Semivolatile Organics Method 8270		
Phenol	10	330
bis (2-Chloroethyl) ether	10	330
2-Chlorophenol	10	330
1,3-Dichlorobenzene	10	330
1,4-Dichlorobenzene	10	330
1,2-Dichlorobenzene	10	330
2-Methylphenol	10	330
2,2'-Oxybis (1-Chloropropane)	10	330
4-Methylphenol	10	330
N-Nitrosodi-n-propylamine	10	330
Hexachloroethane	10	330
Nitrobenzene	10	330
Isophorone	10	330
2-Nitrophenol	10	330
2,4-Dimethylphenol	10	330
bis (2-Chloroethoxy) methane	10	330
2,4-Dichlorophenol	10	330
1,2,4-Trichlorobenzene	10	330
Naphthalene	10	330
4-Chloroaniline	10	330
Hexachlorobutadiene	10	330
4-Chloro-3-methylphenol	10	330
2-Methylnaphthalene	10	330
Hexachlorocyclopentadiene	50	1600
2,4,6-Trichlorophenol	10	330
2,4,5-Trichlorophenol	10	330
2-Chloronaphthalene	10	330
2-Nitroaniline	50	1600
Dimethyl phthalate	10	330
Acenaphthylene	10	330
2,6-Dinitrotoluene	10	330
3-Nitroaniline	50	1600
Acenaphthene	10	330
2,4-Dinitrophenol	50	1600
4-Nitrophenol	50	1600
Dibenzofuran	10	330

- Specific quantitation limits are highly matrix dependent. The limits listed herein are provided for guidance and are not always achievable.
- Quantitation limits listed for solids are based on wet weight. The quantitation limits calculated by the laboratory for solids, calculated on dry weight basis, are higher.

Table 4-1

Quantitation Limits for Organic Chemical Analyses

	Quantitation Limits ^(a)	
	Water (ug/L)	Low Solids ^(b) (ug/kg)
Semivolatile Organics Method 8270		
2,4-Dinitrotoluene	10	330
Diethyl phthalate	10	330
4-Chlorophenyl phenyl ether	10	330
Fluorene	50	330
4-Nitroaniline	50	1600
4,6-Dinitro-2-methylphenol	50	1600
N-Nitrosodiphenylamine	10	330
4-Bromophenyl phenyl ether	10	330
Hexachlorobenzene	10	330
Pentachlorophenol	50	1600
Phenanthrene	10	330
Anthracene	10	330
Carbazole	10	330
Di-n-butyl phthalate	10	330
Fluoranthene	10	330
Pyrene	10	330
Butyl benzyl phthalate	10	330
3,3-Dichlorobenzidine	50	1600
Benzo(a)anthracene	10	330
Chrysene	10	330
bis(2-Ethylhexyl) phthalate	10	330
Di-n-octyl phthalate	10	330
Benzo (b) fluoranthene	10	330
Benzo (k) fluoranthene	10	330
Benzo (a) pyrene	10	330
Indeno (1,2,3-cd) pyrene	10	330
Dibenz (a,h) anthracene	10	330
Benzo (ghi) perylene	10	330

- a. Specific quantitation limits are highly matrix dependent. The limits listed herein are provided for guidance and are not always achievable.
- b. Quantitation limits listed for solids are based on wet weight. The quantitation limits calculated by the laboratory for solids, calculated on dry weight basis, are higher.

Table 4-1

Quantitation Limits for Organic Chemical Analyses

	Quantitation Limits ^(a)	
	Water (ug/L)	Low Solids ^(b) (ug/kg)
Pesticides/PCBs Method 8080		
alpha-BHC	0.05	1.7
beta-BHC	0.05	1.7
delta-BHC	0.05	1.7
gamma-BHC (Lindane)	0.05	1.7
Heptachlor	0.05	1.7
Aldrin	0.05	1.7
Heptachlor Epoxide	0.05	1.7
Endosulfan I	0.05	1.7
Dieldrin	0.05	1.7
4,4'-DDE	0.05	1.7
Endrin	0.05	1.7
Endosulfan II	0.05	1.7
4,4'-DDD	0.05	1.7
Endosulfan Sulfate	0.05	1.7
4,4'-DDT	0.05	1.7
Endrin Ketone	0.05	1.7
Methoxychlor	0.1	3.3
Chlordane	0.05	1.7
Toxaphene	2.0	67
AROCLOR 1016	1.0	33
AROCLOR 1221	1.0	33
AROCLOR 1232	1.0	33
AROCLOR 1242	1.0	33
AROCLOR 1248	1.0	33
AROCLOR 1254	1.0	33
AROCLOR 1260	1.0	33

- a. Specific quantitation limits are highly matrix dependent. The limits listed herein are provided for guidance and are not always achievable.
- b. Quantitation limits listed for solids are based on wet weight. The quantitation limits calculated by the laboratory for solids, calculated on dry weight basis, are higher.

Table 4-2
Soil Sample Collection Information
Greiner's Lagoon Site
Fremont, Ohio

BORING	SAMPLE INTERVAL	CHEMICAL/GEOTECHNICAL ANALYSIS	CHEMICAL ANALYTES	COMPOSITE/DISCRETE SAMPLE
SM-1	1-3	GEOTECHNICAL		
SM-1	5-7	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-1	11-13	GEOTECHNICAL		
SM-1	15-17	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-1	17-19	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-1	21-23	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-2	1-3	GEOTECHNICAL		
SM-2	3-5	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-2	15-17	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-2	17-19	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-2	23-25	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-3	1-3	GEOTECHNICAL		
SM-3	5-7	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-3	9-11	GEOTECHNICAL		
SM-3	15-17	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-3	17-19	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-3	21-23	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-4	1-3	GEOTECHNICAL		
SM-4	5-7	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-4	9-11	GEOTECHNICAL		
SM-4	15-17	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-4	19-21	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-4	21-23	CHEMICAL	VOCS,SVOCS	DISCRETE
SM1-4	5-7	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM1-4	15-17	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM1-4	17-19	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM1-4	21-23	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM-5	2-4	GEOTECHNICAL		
SM-5	5-7	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-5	9-11	GEOTECHNICAL		
SM-5	11-13	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-5	15-17	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-5	20-22	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-6	1-3	GEOTECHNICAL		
SM-6	5-7	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-6	9-11	GEOTECHNICAL		
SM-6	11-13	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-6	15-17	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-6	20-22	CHEMICAL	VOCS,SVOCS	DISCRETE
SM5-6	5-7	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM5-6	11-13	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM5-6	15-17	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM5-6	20-22	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM-7	0-1	CHEMICAL		
SM-7	1-3	GEOTECHNICAL		
SM-7	3-5	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-7	5-7	GEOTECHNICAL		
SM-7	7-9	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-7	11-13	CHEMICAL	VOCS,SVOCS	DISCRETE

Table 4-2
Soil Sample Collection Information
Greiner's Lagoon Site
Fremont, Ohio

BORING	SAMPLE INTERVAL	CHEMICAL/GEOTECHNICAL ANALYSIS	CHEMICAL ANALYTES	COMPOSITE/DISCRETE SAMPLE
SM-7	15-17	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-8	0-1	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-8	1-3	GEOTECHNICAL		
SM-8	3-5	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-8	5-7	GEOTECHNICAL		
SM-8	7-9	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-8	11-13	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-8	15-17	CHEMICAL	VOCS,SVOCS	DISCRETE
SM7-8	3-5	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM7-8	7-9	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM7-8	15-17	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM-9	0-2	GEOTECHNICAL		
SM-9	2-4	GEOTECHNICAL		
SM-9	4-6	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-9	6-8	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-9	8-10	GEOTECHNICAL		
SM-9	12-14	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-10	0-2	GEOTECHNICAL		
SM-10	2-4	GEOTECHNICAL		
SM-10	4-6	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-10	6-8	CHEMICAL	VOCS,SVOCS	DISCRETE
SM-10	8-10	GEOTECHNICAL		
SM-10	12-14	CHEMICAL	VOCS,SVOCS	DISCRETE
SM9-10	4-6	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM9-10	6-8	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SM9-10	12-14	CHEMICAL	PEST/PCBS, METALS	COMPOSITE
SB-1	6-8	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-2	6-8	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-2	30-32	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-3	6-8	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-4	8-10	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-5	6-8	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-5	34-36	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-6	4-6	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-7	6-8	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-7	35-37	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-8	4-6	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-9	4-6	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-9	30-32	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-10	6-8	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-11	0-2	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-12	6-8	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE
SB-13	6-8	CHEMICAL	VOCS,SVOCS, AROCLOR 1254	DISCRETE

TABLE 4-3
GEOPROBE BORING
SOIL AND GROUND WATER
ANALYTICAL RESULTS
Greiner's Lagoon Site
Fremont, Ohio

GB-1 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6'	ND	ND
6-8'	Benzene=33 J	ND
8-10'	2-Butanone=920 4-Methyl 2-Pentanone=5,300	Phenol=790 J
Groundwater	ND	ND

GB-2 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	ND	Bis-2-ethylhexyl phthalate=580 J
2-4'	ND	Bis-2-ethylhexyl phthalate=610 J
4-6'	ND	Bis-2-ethylhexyl phthalate=840 J
6-8' (ERM-Fast)	Acetone=1,800 4-Methyl 2-Pentanone=240	Bis-2-ethylhexyl phthalate=570 J
8-8' (Quanterra)	Acetone=12 J	Bis-2-ethylhexyl phthalate=84 J Naphthalene=76 J
8-10'	2-Butanone=34 J 4-Methyl 2-Pentanone=1,000	Bis-2-ethylhexyl phthalate=540 J
Groundwater	ND	ND

GB-3 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6'	ND	Phenol=500 J
6-8'	Acetone=1,700 4-Methyl 2-Pentanone=1,100	Phenol=100,000 Bis-2-ethylhexyl phthalate=520 J
8-10' (ERM-Fast)	Acetone=4,000 2-Butanone=61 4-Methyl 2-Pentanone=3,400	Phenol=200,000 Bis-2-ethylhexyl phthalate=440 J
8-10' (Quanterra)	Acetone=11,000 J 4-Methyl 2-Pentanone=32,000 J	Phenol=47,000
10-12'	Acetone=18,000 2-Butanone=240 4-Methyl 2-Pentanone=140	Phenol=1,600 Bis-2-ethylhexyl phthalate=630 J
Groundwater	ND	ND

GB-4 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	Acetone=29 J	Bis-2-ethylhexyl phthalate=580 J
2-4'	ND	Bis-2-ethylhexyl phthalate=540 J
4-6'	ND	ND
6-8' (ERM-Fast)	Acetone=1,300 4-Methyl 2-Pentanone=110	Phenol=1,500 Bis-2-ethylhexyl phthalate=720 J
6-8' (Quanterra)	Acetone=4000 J Benzene=360 J 4-Methyl 2-Pentanone=11,000 J	2-Methylphenol=1000 J 4-Methylphenol=590 J Phenol=21,000
Groundwater	Acetone=75	ND

GB-5 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	ND	ND
2-4'	Acetone=28 J	ND
4-6'	ND	ND
6-8' (ERM-Fast)	Acetone=64 Benzene=160	ND
6-8' (Quanterra)	Acetone=14 J Benzene=9	ND
8-10'	Acetone=70	ND
Groundwater	Acetone=27 J	ND

GB-6 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6'	Acetone=80 4-Methyl 2-Pentanone=150	ND
6-8'	Acetone=110 4-Methyl 2-Pentanone=230	ND
8-10'	Acetone=3,600 2-Butanone=61 4-Methyl 2-Pentanone=3,200	Phenol=770 J
Groundwater	ND	ND

TABLE 4-3
GEOPROBE BORING
SOIL AND GROUND WATER
ANALYTICAL RESULTS
Greiner's Lagoon Site
Fremont, Ohio

GB-7 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	Acetone=47 J 4-Methyl 2-Pentanone=72	ND
2-4'	ND	ND
4-6'	ND	ND
6-8'	Acetone=33 J	ND
8-10'	Acetone=97	ND
10-12' (ERM-Fast)	Acetone=20,000 2-Butanone=290 4-Methyl 2-Pentanone=5,800 Toluene=32 J	ND
10-12' (Quanterra)	Acetone=2500 J 4-Methyl 2-Pentanone=680	ND
Groundwater (ERM-Fast)	ND	ND
Groundwater (Quanterra)	ND	ND

GB-8 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6'	ND	ND
6-8'	Acetone=75	ND
8-10'	Acetone=8,600 2-Butanone=200 4-Methyl 2-Pentanone=2,600	ND
10-12'	Acetone=150 4-Methyl 2-Pentanone=36 J	ND
Groundwater	Acetone=28 J	ND

GB-9 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6'	Acetone=93	ND
6-8'	Acetone=34,000 4-Methyl 2-Pentanone=150,000 2-Butanone=300 Toluene=410	Phenol=1,900 Bis-2-ethylhexyl phthalate=3,600
8-10'	Acetone=190,000 2-Butanone=2,000 4-Methyl 2-Pentanone=57,000	ND
Groundwater	Acetone=83 4-Methyl 2-Pentanone=93	ND

GB-10 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	ND	ND
2-4'	Acetone=430 2-Butanone=220 Benzene=97	ND
4-6'	Acetone=77	ND
6-8'	Acetone=57	ND
8-10'	Acetone=180	ND
Groundwater	ND	ND

GB-11 (DEPTH)	VOCS (PPB)	SVOCS (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6'	Acetone=110	ND
6-8' (ERM-Fast)	ND	ND
6-8' (Quanterra)	Acetone=26 J	Bis-2-Ethylhexyl phthalate=57 J
8-10'	Acetone=920 4-Methyl 2-Pentanone=51 J	ND
Groundwater	ND	ND

TABLE 4-3
GEOPROBE BORING
SOIL AND GROUND WATER
ANALYTICAL RESULTS
Greiner's Lagoon Site
Fremont, Ohio

GB-12 (DEPTH)	VOCS (PPB)	SVOCs (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6'	Acetone=100	ND
6-8'	ND	ND
8-10'	Acetone=4,400 2-Butanone=190	ND
Groundwater	ND	ND

GB-13 (DEPTH)	VOCS (PPB)	SVOCs (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6'	Acetone=50	ND
6-8'	ND	ND
8-10'	Acetone=4,200 2-Butanone=110	ND
10-12'	Acetone=65 4-Methyl 2-Pentanone=69	ND
Groundwater	ND	Bis-2-ethylhexyl phthalate=46 J

GB-14 (DEPTH)	VOCS (PPB)	SVOCs (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6' (ERM-Fast)	Acetone=94	ND
4-6' (Quanterra)	ND	ND
6-8'	Acetone=110 4-Methyl 2-Pentanone=37 J	ND
10-12'	Acetone=130	ND
Groundwater	ND	ND

GB-15 (DEPTH)	VOCS (PPB)	SVOCs (PPB)
0-2'	Acetone=42 J	ND
2-4'	Acetone=140 4-Methyl 2-Pentanone=220	ND
4-6' (ERM-Fast)	Acetone=9,100 2-Butanone=130 Benzene=85	ND
4-6' (Quanterra)	ND	ND
6-8' (ERM-Fast)	Acetone=8,200 2-Butanone=130 Benzene=43 J	Phenol=2,300
6-8' (Quanterra)	Acetone=6500 2-Butanone=3800	Phenol=27,000
8-10' (ERM-Fast)	Acetone=30,000 2-Butanone=420 4-Methyl 2-Pentanone=2,500	Phenol=6,700
8-10' (Quanterra)	Acetone=28,000 4-Methyl 2-Pentanone=7,800	Phenol=16,000
Groundwater (ERM-Fast)	ND	ND
Groundwater (Quanterra)	4-Methyl 2-Pentanone=3.7 J	ND

GB-16 (DEPTH)	VOCS (PPB)	SVOCs (PPB)
0-2'	ND	ND
2-4'	ND	ND
4-6'	Acetone=140	ND
6-8'	Acetone=780 4-Methyl 2-Pentanone=3,300 2-Butanone=43 J Benzene=36 J	ND
8-10'	Acetone=610 2-Butanone=140 4-Methyl 2-Pentanone=6,000	ND

GB-17 (DEPTH)	VOCS (PPB)	SVOCs (PPB)
0-2'	ND	ND
2-4' (ERM-Fast)	ND	ND
2-4' (Quanterra)	ND	ND
4-6'	ND	ND
6-8'	Acetone=54	ND

Table 5-1

Summary of Potential Exposure Pathways - Human Health Risk Assessment
Greiner's Lagoon Site, Fremont, Ohio

Medium	Exposure Route/Exposure Point	Potential Receptors - Trespassers		Potential Receptors - Residents*		Potential Receptors - Future Construction Workers	
		Pathway Selected?	Reason for Selection or Exclusion	Pathway Selected?	Reason for Selection or Exclusion	Pathway Selected?	Reason for Selection or Exclusion
Air	Indoor air (VOC vapors) - inhalation	No	Site is secured by perimeter fencing and significant percentage of contaminated soils are stabilized and covered with clean soil, thus reducing potential migration.	No	Site is secured by perimeter fencing and significant percentage of contaminated soil, thus reducing potential migration.	No	No buildings are located at the site. There are no plans for future building construction.
On-Site Soil	On-site soil - ingestion, dermal contact	Yes	Site is secured and affected soils are stabilized and covered with clean soil, thus reducing potential for residential contact. Trespassers could contact the soil.	No	Site is secured and affected soils are stabilized and covered with clean soil, thus reducing potential for residential contact.	Yes	Future on-site workers may contact affected soils if construction activities, such as cap enhancement, occurs.
	Air (VOC vapors or airborne particulates) - inhalation	Yes	Dispersion of vapors/ particulate to adjacent residential areas not expected; on site soils are stabilized, thus reducing potential migration. Trespassers could be exposed to air emissions.	No	Dispersion of vapors/ particulate to adjacent residential areas not expected; on site soils are stabilized, thus reducing potential migration.	Yes	Dispersion of vapors or airborne particulates may occur in work areas.
Off-Site Soil	Off-site soil - ingestion, dermal contact	No	Trespassers may contact affected soils adjacent to the site, however, the conservative residential scenario will be used to evaluate this potential exposure pathway.	Yes	Although residential land use is not expected to occur adjacent to the site, potential exposure for residential receptors may occur.	Yes	Future on-site workers may contact affected soils if construction activities, such as cap enhancements, occurs.
	Air (VOC vapors or airborne particulates) - inhalation	No	Trespassers make contact affected soils adjacent to the site, however, the conservative residential scenario will be used to evaluate this potential exposure pathway.	Yes	Dispersion of vapors/ particulate to adjacent residential areas not expected; however, potential inhalation exposure may occur.	Yes	Dispersion of vapors or airborne particulates may occur in work areas.
On-Site Perched Water	Direct contact, ingestion (current and future potential exposure)	No	Trespassers do not have access to perched ground water. There are no residential wells installed in the perched ground water.	No	There are no residential wells installed in the perched ground water.	Yes	On-site construction workers may have limited contact with shallow perched ground water during excavation/trenching activities.
Off-Site Perched Water	Dermal contact, ingestion (current and future potential exposure)	No	Trespassers do not have access to perched ground water. There are no residential wells installed in the perched ground water.	No	There are no residential wells installed in the perched ground water.	Yes	On-site construction workers may have limited contact with shallow perched ground water during excavation/trenching activities.
Bedrock Ground Water	Dermal contact, ingestion (current and future potential exposure)	No	Trespassers do not have access to ground water.	Yes	Bedrock ground water is a source of residential water supply in the area.	No	On-site construction workers will not have access to the bedrock ground water.
Surface water/ Sediment	Dermal contact, ingestion	Yes	Trespassers may have contact with affected surface water and sediment.	No	Residents will not routinely contact affected surface water and sediment.	Yes	Future on-site workers may have dermal contact with surface water and sediment; ingestion of surface water and sediment is not expected.
Adjacent Crops	Ingestion	No	Little, if any, surface water drains to adjacent farmer's fields. Uptake into plant material expected to be insignificant.	No	Little, if any, surface water drains to adjacent farmer's fields. Uptake into plant material expected to be insignificant.	No	Little, if any, surface water drains to adjacent farmer's fields. Uptake into plant material expected to be insignificant.

* Bedrock ground water is the only potential residential exposure pathway

Table S-2
Exposure Point Concentrations in Air
Off Site Construction Worker in a Trench
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Ground Water Concentration mg/cm ³	MW g/mole	KIL cm/sec	KIG cm/sec	Henry's Law Constant atm-m ³ /mol	KI cm/sec	Area cm ²	Emission Rate mg/sec	Air Concentration mg/m ³
Acetone	4.80E-04	58	4.53E-03	5.63E-01	3.90E-05	7.50E-04	9.E+04	3.24E-02	2.57E-03
4-Methyl-2-pentanone	1.70E-04	100	3.45E-03	4.69E-01	1.40E-04	1.51E-03	9.E+04	2.31E-02	1.83E-03

Table 5-3
Exposure Point Concentrations in Air
On Site Construction Worker in a Trench
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Ground Water Concentration mg/cm ³	MW g/mole	KiL cm/sec	KiG cm/sec	Henry's Law Constant atm-m ³ /mol	Ki cm/sec	Area cm ²	Emission Rate mg/sec	Air Concentration mg/m3
Acetone	1.70E-01	58	4.53E-03	5.63E-01	3.90E-05	7.50E-04	9.E+04	1.15E+01	9.10E-01
Benzene	2.20E-03	78	7.50E-03	6.06E-01	5.50E-03	7.11E-03	9.E+04	1.41E+00	1.12E-01
2-Butanone	2.20E-02	72	4.07E-03	5.24E-01	5.60E-05	9.26E-04	9.E+04	1.83E+00	1.46E-01
Ethylbenzene	3.80E-03	106	6.39E-03	5.19E-01	8.70E-03	6.39E-03	9.E+04	2.19E+00	1.73E-01
4-Methyl-2-pentanone	1.10E-01	100	3.45E-03	4.69E-01	1.40E-04	1.51E-03	9.E+04	1.50E+01	1.19E+00
Naphthalene	4.90E-04	128	5.83E-03	4.90E-01	1.15E-03	5.83E-03	9.E+04	2.57E-01	2.04E-02
Toluene	1.00E-02	92	6.94E-03	5.58E-01	6.60E-03	6.94E-03	9.E+04	6.25E+00	4.96E-01
Xylene	1.90E-02	106	6.39E-03	5.19E-01	5.10E-03	6.39E-03	9.E+04	1.09E+01	8.67E-01

Table 5-4
Data Summaries by Medium
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Number of Detections	Number of Samples	Maximum Concentration	Selected EPC
<u>Bedrock Ground</u>				
Acetone	4	7	0.48	0.48
4-Methyl-2-Pentanone	2	7	0.17	0.17
Phenol	1	6	0.0028	0.0028
bis(2-ethylhexyl)phthalate	3	6	0.0074	0.0074
Lead	5	6	0.014	0.014
Zinc	3	6	0.08	0.08
<u>Perched Off-Site Ground Water</u>				
Acetone	5	10	4	2.75
4-Methyl-2-Pentanone	3	10	15	0.015
Arsenic	8	13	0.041	0.0258
Beryllium	2	13	0.014	0.0055
Cadmium	4	13	0.02	0.0062
Chromium	13	13	0.44	0.2080
Cobalt	2	7	0.35	0.35
Copper	11	13	0.74	0.574
Lead	13	13	0.36	0.190
Mercury	3	13	0.00081	0.0007
Nickel	8	13	0.86	0.860
Zinc	13	13	2.8	1.27
<u>Perched On-Site Ground Water</u>				
Acetone	14	14	170	170
2-Butanone	4	14	22	22
Benzene	9	14	2.250	2.2
4-Methyl-2-Pentanone	9	14	110	110
Toluene	2	14	10	10
Ethylbenzene	2	14	3.8	3.8
Xylenes	3	14	19	19
Phenol	8	14	320	320
2-Methylphenol	1	14	1.2	1.2
4-Methylphenol	2	14	5.1	5.1
Isophorone	1	14	0.53	0.53
Naphthalene	1	14	0.49	0.49
Fluoranthene	1	14	0.01	0.01
bis(2-ethylhexyl)phthalate	2	14	4.7	4.7
Aluminum	1	1	57.5	57.5
Antimony	1	14	0.019	0.008
Arsenic	14	14	0.35	0.143
Barium	1	1	9.05	9.05
Cadmium	6	14	0.023	0.017
Chromium	12	14	0.265	0.265
Cobalt	3	6	0.095	0.095
Copper	13	14	0.63	0.517
Iron	1	1	106	106
Lead	13	14	3.35	3.35
Manganese	1	1	2.25	2.25
Mercury	2	14	0.004	0.001
Nickel	9	14	0.84	0.627
Vanadium	1	1	0.205	0.205
Zinc	14	14	3.5	1.93

Table 5-4
Data Summaries by Medium
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Number of Detections	Number of Samples	Maximum Concentration	Selected EPC
<u>Off-Site Soil</u>				
Acetone	8	11	28	28
2-Butanone	1	11	3.8	3.8
Benzene	2	11	0.75	0.75
4-Methyl-2-Pentanone	4	11	32	32
Phenol	4	11	47	47
2-Methylphenol	1	11	1	1
4-Methylphenol	1	11	0.59	0.59
Naphthalene	1	11	0.076	0.076
bis(2-ethylhexyl)phthalate	2	11	0.084	0.084
Arsenic	8	8	9.1	9.1
Cadmium	1	8	0.27	0.2
Chromium	8	8	17.4	17.4
Copper	8	8	27.3	27.3
Lead	8	8	13.5	13.5
Nickel	8	8	33.3	33.3
Zinc	8	8	81.3	81.3
<u>On-Site Soil</u>				
Acetone	19	36	32	32
Benzene	14	36	27	27
2-Butanone	8	36	1.9	1.9
Ethylbenzene	12	36	110	110
2-Hexanone	2	22	0.0053	0.0053
4-Methyl-2-pentanone	23	36	140	140
Styrene	2	35	3.8	3.8
1,1,2,2-Tetrachloroethane	2	22	0.47	0.47
Toluene	15	36	330	330
Trichloroethene	5	36	9.5	9.5
Total Xylenes	16	36	520	520
Butyl benzyl phthalate	1	35	86	86
2-Chlorophenol	1	23	0.13	0.13
1,2-Dichlorobenzene	7	36	230	230
1,4-Dichlorobenzene	2	36	91	91
2,4-Dimethylphenol	2	35	1.2	1.2
Di-n-butyl phthalate	1	35	36	36
bis(2-Ethylhexyl)phthalate	27	36	4,000	4,000
Isophorone	4	36	0.1	0.1
2-Methylnaphthalene	6	36	130	130
2-Methylphenol	5	36	1.9	1.9
4-Methylphenol	5	36	2	2
Naphthalene	6	36	86	86
Phenanthrene	3	35	0.52	0.52
Phenol	18	36	430	430
Pyrene	1	23	0.12	0.12
1,2,4-Trichlorobenzene	6	36	350	350
Aroclor 1254	4	23	38	38
Endrin ketone	1	10	0.63	0.63
Antimony	1	11	6.2	1.7
Arsenic	11	11	14.2	10.8
Cadmium	8	11	43.7	43.7
Chromium	11	11	94.6	36.7
Copper	11	11	102	52.5
Lead	11	11	811	811

Table 5-4
Data Summaries by Medium
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Number of Detections	Number of Samples	Maximum Concentration	Selected EPC
<u>On-Site Soil (con t)</u>				
Mercury	3	11	1.3	0.5
Nickel	11	11	31.4	23.6
Selenium	1	11	3.4	0.9
Zinc	11	11	2,470	1,105.3
<u>Surface Water</u>				
bis(2-Ethylhexyl)phthalate	1	4	0.008	0.008
Lead	1	4	0.0061	0.0061
<u>Sediment</u>				
Acetone	1	4	0.074	0.074
2-Butanone	1	4	0.017	0.017
bis(2-Ethylhexyl)phthalate	1	4	0.06	0.06
Arsenic	4	4	6.4	6.4
Chromium	4	4	9.8	9.8
Copper	4	4	15.6	15.6
Lead	4	4	10.3	10.3
Nickel	4	4	16.7	16.7
Zinc	4	4	77.2	77.2

All water data reported in units of mg/L and soil/sediment data reported in units of mg/kg.
EPC - Exposure Point Concentration. Selected EPC is the lower value of either the maximum concentration detected or the calculated 95% upper confidence limit of the data set mean (see Appendix J)

Table 5-5
Comparison to Background Concentrations
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Maximum or 95% UCL Soil Concentrations	Site-Specific Background Concentrations*	Background Exceeded?
Metals (mg/kg)			
Antimony	1.7	1.1-1.4**	Yes
Arsenic	10.8 ^	11.2	No
Cadmium	43.7 ^	2.2	Yes
Chromium	36.7	13.3	Yes
Copper	52.5	19.6	Yes
Lead	811 ^	11.4	Yes
Mercury	0.50	0.11-0.14**	Yes
Nickel	33.30	12.7	Yes
Selenium	0.90	0.55-1.2**	No
Zinc	1,105	56.2	Yes

Notes:

mg/kg - milligrams per kilogram

^ 95% UCL soil concentration (or maximum concentration) derived for on-site and off-site soil samples (see Attachment B). 95% UCL calculation followed procedure outlined in Section 5.2.3..

* Derivation of calculated background concentration provided in Section 5.2.4.

** This metal was analyzed but not detected in the background samples.

The numerical values represent the range of quantitation limits for the background samples.

Table 5-6
Toxicity Criteria
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Oral Reference Dose (mg/kg/day)	Inhalation Reference Dose (mg/kg/day)	Oral Cancer Slope Factor (mg/kg-day) ⁻¹	Inhalation Cancer Slope Factor (mg/kg-day) ⁻¹	Oral Absorption Factor (%)	Dermal Reference Dose (mg/kg/day)	Dermal Cancer Slope Factor (mg/kg-day) ⁻¹	Oral Absorption Factor References	Permeability Constants (cm/hr)
Acetone	1.00E-01	NA	NA	NA	0.83	8.30E-02	NA	NCEA, 1992	5.70E-04
Benzene	3.00E-03	1.71E-03	2.90E-02	2.90E-02	1	3.00E-03	2.90E-02	IRIS	1.10E-01
2-Butanone	6.00E-01	2.86E-01	NA	NA	1	6.00E-01	NA		5.00E-03
Ethylbenzene	1.00E-01	2.86E-01	NA	NA	0.92	9.20E-02	NA	NCEA, 1993	1.00E+00
2-Hexanone	8.00E-02	2.29E-02	NA	NA	1	8.00E-02	NA		1.55E-03
4-Methyl-2-pentanone	8.00E-02	2.00E-02	NA	NA	1	8.00E-02	NA		1.55E-03
Styrene	2.00E-01	2.90E-01	NA	NA	0.9	1.80E-01	NA	HEA, 1989	6.70E-01
1,1,2,2-Tetrachloroethane	6.00E-02	NA	2.00E-01	2.00E-01	1	6.00E-02	2.00E-01		9.00E-03
Toluene	2.00E-01	1.14E-01	NA	NA	1	2.00E-01	NA	NCEA, 1992	1.00E+00
Trichloroethene	6.00E-03	NA	1.10E-02	6.00E-03	1	6.00E-03	1.10E-02		2.30E-01
Xylenes	2.00E+00	NA	NA	NA	0.92	1.84E+00	NA	NCEA, 1992	8.00E-02
Bis(2-ethylhexyl) phthalate	2.00E-02	NA	1.40E-02	1.40E-02	0.55	1.10E-02	2.55E-02	ATSDR, 1991	3.30E-02
Butyl benzyl phthalate	2.00E-01	NA	NA	NA	0.9	1.80E-01	NA	HEED, 1985	3.30E-02
2-Chlorophenol	5.00E-03	NA	NA	NA	1	5.00E-03	NA	Owen, 1990	3.30E-02
1,2-Dichlorobenzene	9.00E-02	9.00E-03	NA	NA	1	9.00E-02	NA		6.10E-02
1,4-Dichlorobenzene	3.00E-02	2.29E-01	2.40E-02	2.20E-02	1	3.00E-02	2.40E-02		6.20E-02
2,4-Dimethylphenol	2.00E-02	NA	NA	NA	1	2.00E-02	NA		1.10E-01
Di-n-butyl phthalate	1.00E-01	NA	NA	NA	0.85	8.50E-02	NA	Owen, 1990	3.30E-02
Fluoranthene	4.00E-02	NA	NA	NA	0.7	2.80E-02	NA	ATSDR, 1993	3.60E-01
Isophorone	2.00E-01	NA	9.50E-04	NA	0.5	1.00E-01	1.90E-03		4.20E-03
2-Methylnaphthalene	2.00E-02	NA	NA	NA	1	2.00E-02	NA	Owen, 1990	6.90E-02
2-Methylphenol	5.00E-02	NA	NA	NA	0.8	4.00E-02	NA	HEED, 1985	1.50E-02
4-Methylphenol	5.00E-03	NA	NA	NA	0.8	4.00E-03	NA	HEED, 1985	1.60E-02
Naphthalene	2.00E-02	9.00E-04	NA	NA	1	2.00E-02	NA	Owen, 1990	6.90E-02
Phenanthrene	3.00E-02	NA	NA	NA	0.6	1.80E-02	NA	DWCD, 1980	2.30E-01
Phenol	6.00E-01	NA	NA	NA	0.9	5.40E-01	NA	HEA, 1989	8.20E-03
Pyrene	3.00E-02	NA	NA	NA	0.8	2.40E-02	NA	ATSDR, 1993	NA
1,2,4-Trichlorobenzene	1.00E-02	5.71E-02	NA	NA	0.3	3.00E-03	NA	as chlorobenzene (HEA, 1989)	1.00E-01
Aroclor 1254	2.00E-05	NA	2.00E+00	2.00E+00	0.95	1.90E-05	2.11E+00	Owen, 1990	1.30E+00
Endrin ketone	3.00E-04	NA	NA	NA	0.5	1.50E-04	NA	ATSDR, 1992	1.60E-02
Aluminum	1.00E+00	1.00E-03	NA	NA	0.27	2.70E-01	NA	ATSDR, 1992	1.00E-03
Antimony	4.00E-04	NA	NA	NA	0.1	4.00E-05	NA	ATSDR, 1992	1.00E-03
Arsenic	3.00E-04	NA	1.50E+00	1.50E+01	0.95	2.85E-04	1.58E+00	NCEA, 1992	1.00E-03
Barium	7.00E-02	1.40E-04	NA	NA	1	7.00E-02	NA	NCEA, 1993	1.00E-03
Beryllium	2.00E-03	5.70E-06	NA	8.40E+00	0.01	2.00E-05	NA	NCEA, 1994	1.00E-03
Cadmium (water)	5.00E-04	NA	NA	6.30E+00	0.05	2.50E-05	NA	IRIS	1.00E-03
Cadmium (food)	1.00E-03	NA	NA	6.30E+00	0.025	2.50E-05	NA	IRIS	1.00E-03

Table 5-6
Toxicity Criteria
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Oral Reference Dose (mg/kg/day)	Inhalation Reference Dose (mg/kg/day)	Oral Cancer Slope Factor (mg/kg-day) ⁻¹	Inhalation Cancer Slope Factor (mg/kg-day) ⁻¹	Oral Absorption Factor (%)	Dermal Reference Dose (mg/kg/day)	Dermal Cancer Slope Factor (mg/kg-day) ⁻¹	Oral Absorption Factor References	Permeability Constants (cm/hr)
Chromium (as Cr+3)	1.50E+00	5.71E-07	NA	NA	0.04	6.00E-02	NA	ATSDR, 1988/1989	1.00E-03
Chromium (as Cr+6)	3.00E-03	3.00E-05	NA	4.10E+01	0.04	1.20E-04	NA	ATSDR, 1988/1989	1.00E-03
Cobalt	6.00E-02	NA	NA	NA	0.3	1.80E-02	NA	ATSDR, 1992	1.00E-03
Copper	4.00E-02	NA	NA	NA	0.6	2.40E-02	NA	NCEA, 1992	1.00E-03
Iron	3.00E-01	NA	NA	NA	1	3.00E-01	NA		1.00E-03
Lead	NA	NA	NA	NA	NA	NA	NA		1.00E-03
Manganese	2.00E-02	1.43E-05	NA	NA	0.04	8.00E-04	NA		1.00E-03
Mercury	3.00E-04	8.57E-05	NA	NA	0.15	4.50E-05	NA	NCEA, 1993	1.00E-03
Nickel	2.00E-02	NA	NA	NA	0.05	1.00E-03	NA	Owen, 1990	1.00E-03
Selenium	5.00E-03	NA	NA	NA	0.9	4.50E-03	NA	ATSDR, 1994	1.00E-03
Vanadium	7.00E-03	NA	NA	NA	0.02	1.40E-04	NA	ATSDR, 1992	1.00E-03
Zinc	3.00E-01	NA	NA	NA	0.5	1.50E-01	NA	Owen, 1990	1.00E-03

Notes:

Toxicity criteria taken from USEPA Region III RBC Table, October 1998. Toxicity value for pyrene used as a surrogate for phenanthrene.

NA - Not available.

ATSDR - Agency for Toxic Substances and Disease Registry

DWCD - Drinking Water Criteria Document

HEA - Health Effects Assessment Document

HEED - Health and Environmental Effects Document

IRIS - Integrated Risk Information System

Owen, B. A. Literature-Derived Absorption Coefficients for 39 Chemicals via Oral and Inhalation Routes of Exposure. Reg. Toxicol. and Pharmacol. 11, 237-252 (1990).

Permeability constants taken from Dermal Assessment Manual (EPA, 1992).

Table 5-7
Ingestion of Bedrock Ground Water by Child Resident
Greiner's Lagoon Site
Fremont, Ohio

$\text{Intake (mg/kg-day)} = \frac{\text{Cw} \cdot \text{IR} \cdot \text{EF} \cdot \text{ED}}{\text{BW} \cdot \text{AT}}$							
Cw = Concentration in water (mg/l) = Chemical-specific IR - Ingestion rate (liters/day) = 1 [EPA, 1991] EF - Exposure frequency (days/year) = 350 [EPA, 1991] ED - Exposure Duration (years) = 6 [EPA, 1991] BW - Body weight (kg) = 15 [EPA, 1991] ATn - Averaging time noncarcinogenic (days) = 2,190 ATc - Averaging time carcinogenic (days) = 25,550							
Constituent	Concentration in water (mg/l)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)-1	Cancer Slope Factor (mg/kg-day)-1	Cancer Risk
Acetone	0.48	3.07E-02	1.0E-01	3.1E-01	2.6E-03	NA	NA
4-Methyl-2-pentanone	0.17	1.09E-02	8.0E-02	1.4E-01	9.3E-04	NA	NA
Bis(2-ethylhexyl)phthalate	0.0074	4.73E-04	2.0E-02	2.4E-02	4.1E-05	1.4E-02	5.7E-07
Phenol	0.0028	1.79E-04	6.0E-01	3.0E-04	1.5E-05	NA	NA
Zinc	0.08	5.11E-03	3.0E-01	1.7E-02	4.4E-04	NA	NA
TOTAL HI =				4.8E-01	TOTAL CANCER RISK =		5.7E-07

Table 5-8
Dermal Exposure to Bedrock Ground Water by Child Resident
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_w \cdot SA \cdot PC \cdot ET \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

C_w = Concentration in water (mg/l) = Chemical-specific
 SA - Skin surface area available for exposure (cm²) = 8,000 [100% total body surface area (EPA, 1991)]
 PC - Dermal permeability constant (cm/hr) = Chemical-specific (see Table 5-6)
 ET - Exposure time (hours/day) = 0.2
 EF - Exposure frequency (days/year) = 350 [EPA, 1991]
 ED - Exposure Duration (years) = 6 [EPA, 1991]
 CF - Conversion Factor (1 L/1000 cm³) = 1.00E-03
 BW - Body weight (kg) = 15 [EPA, 1991]
 AT_n - Averaging time noncarcinogenic (days) = 2,190
 AT_c - Averaging time carcinogenic (days) = 25,550

Constituent	Concentration in water (mg/l)	Average Daily Intake (mg/kg-day)	Reference Dose (Dermal) (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg/day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	0.48	2.8E-05	8.3E-02	3.4E-04	2.4E-06	NA	NA
4-Methyl-2-pentanone	0.17	2.7E-05	8.0E-02	3.4E-04	2.3E-06	NA	NA
Bis(2-ethylhexyl)phthalate	0.0074	2.5E-05	1.1E-02	2.3E-03	2.1E-06	2.5E-02	5.4E-08
Phenol	0.0028	2.3E-06	5.4E-01	4.3E-06	2.0E-07	NA	NA
Zinc	0.08	8.2E-06	1.5E-01	5.5E-05	7.0E-07	NA	NA
TOTAL HI =				3.0E-03	TOTAL CANCER RISK =		5.4E-08

Table 5-9
Ingestion of Bedrock Ground Water by Adult Residents
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_s \cdot IR \cdot EF \cdot ED}{BW \cdot AT}$$

Cs = Concentration in water (mg/l) = Chemical-specific
 IR - Ingestion rate (liters/day) = 2 [EPA, 1991]
 EF - Exposure frequency (days/year) = 350 [EPA, 1991]
 ED - Exposure Duration (years) = 30 [EPA, 1991]
 BW - Body weight (kg) = 70 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 10,950
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Concentration in water (mg/l)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)-1	Cancer Slope Factor (mg/kg-day)-1	Cancer Risk
Acetone	0.48	1.3E-02	1.0E-01	1.3E-01	5.6E-03	NA	NA
4-Methyl-2-pentanone	0.17	4.7E-03	8.0E-02	5.8E-02	2.0E-03	NA	NA
Bis(2-ethylhexyl)phthalate	0.0074	2.0E-04	2.0E-02	1.0E-02	8.7E-05	1.4E-02	1.2E-06
Phenol	0.0028	7.7E-05	6.0E-01	1.3E-04	3.3E-05	NA	NA
Zinc	0.08	2.2E-03	3.0E-01	7.3E-03	9.4E-04	NA	NA
TOTAL HI =				2.1E-01	TOTAL CANCER RISK =		1.2E-06

Table 5-10
Dermal Exposure to Bedrock Ground Water by Adult Resident
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_w \cdot SA \cdot PC \cdot ET \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

Cw = Concentration in water (mg/l) = Chemical-specific
 SA - Skin surface area available for exposure (cm²) = 20,000 [100% total body surface area (EPA, 1991)]
 PC - Dermal permeability constant (cm/hr) = Chemical-specific (see Table 5-6)
 ET - Exposure time (hours/day) = 0.2
 EF - Exposure frequency (days/year) = 350 [EPA, 1991]
 ED - Exposure Duration (years) = 30 [EPA, 1991]
 CF - Conversion Factor (1 L/1000 cm³) = 1.00E-03
 BW - Body weight (kg) = 70 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 10,950
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Concentration in water (mg/l)	Average Daily Intake (mg/kg-day)	Reference Dose (Dermal) (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg/day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	0.48	1.5E-05	8.3E-02	1.8E-04	6.4E-06	NA	NA
4-Methyl-2-pentanone	0.17	1.4E-05	8.0E-02	1.8E-04	6.2E-06	NA	NA
Bis(2-ethylhexyl)phthalate	0.0074	1.3E-05	1.1E-02	1.2E-03	5.7E-06	2.5E-02	1.4E-07
Phenol	0.0028	1.3E-06	5.4E-01	2.3E-06	5.4E-07	NA	NA
Zinc	0.08	4.4E-06	1.5E-01	2.9E-05	1.9E-06	NA	NA
TOTAL HI =				1.6E-03	TOTAL CANCER RISK =		1.4E-07

Table 5-10a

Bedrock Ground Water Inhalation Intake Factor Assumptions - Showering Scenario
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Maximum Concentration (C) mg/l	MW g/mol	Henry's Law Constant (H)* atm-m ³ /mol	k _g cm/hr	k _l cm/hr	K _L cm/hr	K _{adj} cm/hr	C*WD μg/l	S μg/m ³ /min	Q -	D mg/kg/shower
acetone	4.80E-01	58	3.88E-05	1.67E+03	1.74E+01	2.34E+00	1.16E+00	4.79E+01	1.60E+02	2.482	4.76E-03
4-methyl-2-pentanone	1.70E-01	100	1.40E-04	1.27E+03	1.33E+01	4.76E+00	6.43E+00	3.28E+01	1.09E+02	2.482	1.25E-03
										2.482	
										2.482	

Notes:

* - Soil Screening Guidance - Technical Background Document (USEPA, 1996).

Calculated Parameters (Paster and Chrostowski, 1987):

$k_g = k_H \times \text{SQRT}(MW \text{ H}_2\text{O}/MW)$, where k_g is the gas-film mass transfer coefficient (cm/hr)

$k_l = k_C \times \text{SQRT}(MW \text{ C}/MW)$, where k_l is the liquid-film mass transfer coefficient (cm/hr)

$K_L = 1/((1/k_l) + ((R \times T)/(H \times k_g)))$, where K_L is the mass transfer coefficient (cm/hr)

$K_{adj} = K_L/\text{SQRT}((T_1 \times US)/(T_S \times UI))$, where K_{adj} is the adjusted overall mass transfer coefficient (cm/hr)

$C*WD = C \times CF \times (1 - \text{EXP}((-K_{adj} \times ts)/(60 \times d)))$, where $C*WD$ is the concentration leaving the shower droplet after time ts (μg/l)

$S = C*WD \times FR / SV$, where S is the indoor VOC generation rate (μg/m³/min)

$Q = Ds + ((\text{EXP}(-Ra \times Dt))/Ra) - ((\text{EXP}(Ra \times (Ds \times Dt)))/Ra)$

$D = ((VR \times S)/(BW \times Ra \times 1E6)) \times Q$, where D is the inhalation dose (mg/kg/shower)

Input Variables:	Value	Units
k_g for water, k_H =	3000	cm/hr
molecular weight for water, $MW \text{ H}_2\text{O}$ =	18	g/mol
k_l for carbon dioxide, k_C =	20	cm/hr
molecular weight for carbon dioxide, $MW \text{ C}$ =	44	g/mol
gas constant, R =	0.000082	atm-m ³ /mol-K
absolute temperature, T =	293	K
calibrated water temperature of K_L , T_1 =	293	K
shower water temperature, T_S =	318	K
water viscosity at T_1 , UI =	1.002	cp
water viscosity at T_S , US =	0.596	cp
conversion factor, CF =	1000	μg/mg
shower droplet diameter, d =	1	mm
shower droplet time, ts =	2	sec
shower flow rate, FR =	20	l/min
shower room air volume, SV =	6	m ³
shower duration, Ds =	12	min
total duration in shower room, Dt =	20	min
rate of air exchange, Ra =	0.01667	1/min
ventilation rate, VR =	14	l/min
body weight, BW =	70	kg

Table 5-10a

Bedrock Ground Water Inhalation Intake Factor Assumptions - Showering Scenario (con't)

Greiner's Lagoon Site

Fremont, Ohio

Constituent	Receptor	Inhalation Dose mg/kg/shower	Exposure Frequency (1) d/yr	Exposure Duration (2) yr	Noncarcinogenic Averaging Time days	Carcinogenic Averaging Time days	Noncarcinogenic Dose mg/kg-d	Carcinogenic Dose mg/kg-d	Noncarcinogenic Risk	Carcinogenic Risk
acetone	adult	4.76E-03	350	24	8760	25550	4.56E-03	1.56E-03	4.56E-02	NA
4-methyl-2-pentanone	adult	3.25E-03	350	24	8760	25550	3.12E-03	1.07E-03	1.56E-01	NA
acetone	child	4.76E-03	350	6	2190	25550	4.56E-03	3.91E-04	2.28E-01	NA
4-methyl-2-pentanone	child	3.25E-03	350	6	2190	25550	3.12E-03	2.67E-04	1.56E-01	NA

Notes:

(1) Default exposure frequency for residential adults and children (USEPA, 1991).

(2) Default exposure duration for residential adults and children (USEPA, 1991).

NA - Volatile organic constituents are not carcinogenic.

Total Risk - Adult 2E-01 NA

Total Risk - Child 4E-01 NA

Table 5-11

**Dermal Exposure to Perched Off-Site Ground Water by Construction Worker
Greiner's Lagoon Site
Fremont, Ohio**

$$\text{Intake (mg/kg-day)} = \frac{C_w \cdot SA \cdot PC \cdot ET \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

C_w = Concentration in water (mg/l) = Chemical-specific

SA - Skin surface area available for exposure (cm²) = 7,000 [hands, forearms, lower legs, feet (EPA, 1997)]

PC - Dermal permeability constant (cm/hr) = Chemical-specific (see Table 5-6)

ET - Exposure time (hours/day) = 1

EF - Exposure frequency (days/year) = 20 [professional judgment]

ED - Exposure Duration (years) = 1 [EPA, 1991]

CF - Conversion Factor (1 L/1000 cm³) = 1.00E-03

BW - Body weight (kg) = 70 [EPA, 1991]

AT_n - Averaging time noncarcinogenic (days) = 365

AT_c - Averaging time carcinogenic (days) = 25,550

Constituent	Concentration in water (mg/l)	Average Daily Intake (mg/kg-day)	Reference Dose (Dermal) (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg/day)	Cancer Slope Factor (Dermal) (mg/kg-day) ⁻¹	Cancer Risk
Acetone	2.75	8.6E-06	8.3E-02	1.0E-04	1.2E-07	NA	NA
4-Methyl-2-pentanone	0.015	1.3E-07	8.0E-02	1.6E-06	1.8E-09	NA	NA
Arsenic	0.0258	1.4E-07	2.8E-04	5.0E-04	2.0E-09	1.6E+00	3.2E-09
Beryllium	0.0055	3.8E-08	2.0E-05	1.5E-03	4.3E-10	NA	NA
Cadmium (as water)	0.0062	3.4E-08	2.5E-05	1.4E-03	4.9E-10	NA	NA
Chromium (as Cr +3)	0.1791	9.8E-07	6.0E-02	1.6E-05	1.4E-08	NA	NA
Chromium (as Cr+6)	0.029	1.6E-07	1.2E-04	1.3E-03	2.3E-09	NA	NA
Cobalt	0.35	1.9E-06	1.8E-02	1.1E-04	2.7E-08	NA	NA
Copper	0.574	3.1E-06	2.4E-02	1.3E-04	4.5E-08	NA	NA
Mercury	0.0007	3.8E-09	4.5E-05	8.5E-05	5.5E-11	NA	NA
Nickel	0.86	4.7E-06	1.0E-03	4.7E-03	6.7E-08	NA	NA
Zinc	1.27	7.0E-06	1.5E-01	4.6E-05	9.9E-08	NA	NA
TOTAL HI =				9.9E-03	TOTAL CANCER RISK =		3.2E-09

Table 5-12

*Inhalation of Airborne Chemicals from Perched Off-Site Ground Water by Construction Worker
Greiner's Lagoon Site
Fremont, Ohio*

$$\text{Intake (mg/kg-day)} = \frac{\text{Ca} \cdot \text{IR} \cdot \text{ET} \cdot \text{EF} \cdot \text{ED}}{\text{BW} \cdot \text{AT}}$$

Ca = Concentration in air (mg/m³) = Chemical-specific
 IR - Inhalation rate (m³/hour) = 2.5 [EPA, 1997]
 ET - Exposure time (hours/day) = 2
 EF - Exposure frequency (days/year) = 20 [professional judgment]
 ED - Exposure Duration (years) = 1
 BW - Body weight (kg) = 70 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 365
 ATc - Averaging time carcinogenic (days) = 25550

Constituent	Air Concentration (mg/m ³)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	2.57E-03	1.0E-05	NA	NA	1.4E-07	NA	NA
4-Methyl-2-pentanone	1.83E-03	7.2E-06	2.0E-02	3.6E-04	1.0E-07	NA	NA

TOTAL HI = 3.6E-04 TOTAL CANCER RISK = 0.0E+00

Table 5-13

Dermal Exposure to Perched On-Site Ground Water by Construction Worker

Greiner's Lagoon Site

Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_w \cdot SA \cdot PC \cdot ET \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

C_w = Concentration in water (mg/l) = Chemical-specific
 SA = Skin surface area available for exposure (cm²) = 7,000 [hands, forearms, lower legs, feet (EPA, 1997)]
 PC = Dermal permeability constant (cm/hr) = Chemical-specific (see Table 5-6)
 ET = Exposure time (hours/day) = 1
 EF = Exposure frequency (days/year) = 20 [professional judgment]
 ED = Exposure Duration (years) = 1 [EPA, 1991]
 CF = Conversion Factor (1 L/1000 cm³) = 1.00E-03
 BW = Body weight (kg) = 70 [EPA, 1991]
 AT_n = Averaging time noncarcinogenic (days) = 365
 AT_c = Averaging time carcinogenic (days) = 25,550

Constituent	Concentration in water (mg/l)	Average Daily Intake (mg/kg-day)	Reference Dose (Dermal) (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg/day)	Cancer Slope Factor (Dermal) (mg/kg-day) ⁻¹	Cancer Risk
Acetone	170	5.3E-04	8.3E-02	6.4E-03	7.6E-06	NA	NA
2-Butanone	22	6.0E-04	6.0E-01	1.0E-03	8.6E-06	NA	NA
Benzene	2.2	1.3E-03	3.0E-03	4.4E-01	1.9E-05	2.9E-02	5.5E-07
4-Methyl-2-pentanone	110	9.3E-04	8.0E-02	1.2E-02	1.3E-05	NA	NA
Toluene	10	5.5E-02	2.0E-01	2.7E-01	7.8E-04	NA	NA
Ethylbenzene	3.8	2.1E-02	9.2E-02	2.3E-01	3.0E-04	NA	NA
Xylenes	19	8.3E-03	1.8E+00	4.5E-03	1.2E-04	NA	NA
Phenol	320	1.4E-02	5.4E-01	2.7E-02	2.1E-04	NA	NA
2-Methylphenol	1.2	9.9E-05	4.0E-02	2.5E-03	1.4E-06	NA	NA
4-Methylphenol	5.1	4.5E-04	4.0E-03	1.1E-01	6.4E-06	NA	NA
Isophorone	0.53	1.2E-05	1.0E-01	1.2E-04	1.7E-07	1.9E-03	3.3E-10
Naphthalene	0.49	1.9E-04	2.0E-02	9.3E-03	2.6E-06	NA	NA
Fluorenone	0.01	2.0E-05	2.8E-02	7.0E-04	2.8E-07	NA	NA
Bis(2-ethylhexyl)phthalate	4.7	8.5E-04	1.1E-02	7.7E-02	1.2E-05	2.6E-02	3.1E-07
Aluminum	57.5	3.2E-04	2.7E-01	1.2E-03	4.5E-06	NA	NA
Antimony	0.008	4.4E-08	4.0E-05	1.1E-03	6.3E-10	NA	NA
Arsenic	0.143	7.8E-07	2.8E-04	2.8E-03	1.1E-08	1.6E+00	1.8E-08
Barium	9.05	5.0E-05	7.0E-02	7.1E-04	7.1E-07	NA	NA
Cadmium (as water)	0.017	9.3E-08	2.5E-05	3.7E-03	1.3E-09	NA	NA
Chromium (as Cr +3)	0.227	1.2E-06	6.0E-02	2.1E-05	1.8E-08	NA	NA
Chromium (as Cr +6)	0.038	2.1E-07	1.2E-04	1.7E-03	3.0E-09	NA	NA
Cobalt	0.095	5.2E-07	1.8E-02	2.9E-05	7.4E-09	NA	NA
Copper	0.517	2.8E-06	2.4E-03	1.2E-03	4.0E-08	NA	NA
Iron	106	5.8E-04	3.0E-01	1.9E-03	8.3E-06	NA	NA
Manganese	2.25	1.2E-05	8.0E-04	1.5E-02	1.8E-07	NA	NA
Mercury	0.001	5.5E-09	4.5E-05	1.2E-04	7.8E-11	NA	NA
Nickel	0.627	3.4E-06	1.0E-03	3.4E-03	4.9E-08	NA	NA
Vanadium	0.205	1.1E-06	1.4E-04	8.0E-03	1.6E-08	NA	NA
Zinc	1.93	1.1E-05	1.5E-01	7.1E-05	1.5E-07	NA	NA
TOTAL HI =				1.2E+00	TOTAL CANCER RISK =		8.8E-07

Table 5-14

**Inhalation of Airborne Chemicals from Perched On-Site Ground Water by Construction Workers
Greiner's Lagoon Site
Fremont, Ohio**

$$\text{Intake (mg/kg-day)} = \frac{\text{Ca} \cdot \text{IR} \cdot \text{ET} \cdot \text{EF} \cdot \text{ED}}{\text{BW} \cdot \text{AT}}$$

Ca = Concentration in air (mg/m³) = Chemical-specific
 IR - Inhalation rate (m³/hour) = 2.5 [EPA, 1997]
 ET - Exposure time (hours/day) = 2
 EF - Exposure frequency (days/year) = 20 [professional judgment]
 ED - Exposure Duration (years) = 1
 BW - Body weight (kg) = 70 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 365
 ATc - Averaging time carcinogenic (days) = 25550

Constituent	Air Concentration (mg/m ³)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	9.10E-01	3.6E-03	NA	NA	5.1E-05	NA	NA
Benzene	1.12E-01	4.4E-04	1.7E-03	2.6E-01	6.2E-06	2.9E-02	1.8E-07
2-Butanone	1.46E-01	5.7E-04	2.9E-01	2.0E-03	8.1E-06	NA	NA
Ethylbenzene	1.73E-01	6.8E-04	2.9E-01	2.4E-03	9.7E-06	NA	NA
4-Methyl-2-pentanone	1.19E+00	4.6E-03	2.0E-02	2.3E-01	6.6E-05	NA	NA
Toluene	4.96E-01	1.9E-03	1.1E-01	1.7E-02	2.8E-05	NA	NA
Xylenes	8.67E-01	3.4E-03	NA	NA	4.8E-05	NA	NA
Naphthalene	2.04E-02	8.0E-05	9.0E-04	8.9E-02	1.1E-06	NA	NA

TOTAL HI = 6.0E-01

TOTAL CANCER RISK = 1.8E-07

Table 5-15
Calculation of Volatilization Factors for Organic Compounds Detected in Soils
Greiner's Lagoon Site
Fremont, Ohio

	Q/C	Diffusivity		Diffusivity		Henry's Law		Koc	Kd	Da	VF		
		in air		in water		Constant							
		(cm2/sec)		(cm2/sec)		(unitless)							
Organic Compounds													
Acetone	50.38	0.12400	s	1.14E-05	s	1.59E-03	s	0.575	s	0.0115	a	0.00097	2.95E+03
Benzene	50.38	0.08800	s	9.80E-06	s	1.37E-04	s	58.9	s	1.178	a	0.00002	2.11E+04
2-Butanone	50.38	0.0948	d	9.40E-06	m	1.91E-03	m	33.88	m	0.6776	a	0.00013	8.20E+03
Ethylbenzene	50.38	0.07500	s	7.80E-06	s	3.23E-01	s	363	s	7.26	a	0.00143	2.42E+03
2-Hexanone	50.38	0.09480	d	7.80E-06	m	7.18E-02	m	134.8		2.696	a	0.00107	2.81E+03
4-Methyl-2-pentanone	50.38	0.09480	d	7.70E-06	m	1.60E-02	m	6.16		0.1232	a	0.00300	1.67E+03
Styrene	50.38	0.07100	s	8.00E-06	s	1.13E-01	s	776	s	15.52	a	0.00023	6.11E+03
1,1,2,2-Tetrachloroethane	50.38	0.07100	s	7.90E-06	s	1.41E-02	s	93.3	s	1.866	a	0.00023	6.04E+03
Toluene	50.38	0.08700	s	8.60E-06	s	2.72E-01	s	182	s	3.64	a	0.00274	1.75E+03
Trichloroethene	50.38	0.07900	s	9.10E-06	s	4.22E-01	s	166	s	3.32	a	0.00418	1.42E+03
Total Xylenes	50.38	0.07690	s	8.44E-06	s	3.14E-01	s	389	s	7.78	a	0.00133	2.51E+03

Notes:

d = USEPA, 1988. Superfund Exposure Assessment Manual (SEAM).

m = Montgomery, 1996. Groundwater Chemicals Desk Reference.

s = USEPA 1996a. Soil Screening Guidance: Technical Background Document.

a = $Koc \cdot f_{oc}$, where $f_{oc}=0.02$

Table 5-16
Ingestion of Off-Site Soil by Construction Workers
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_s \cdot IR \cdot FI \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

Cs = Concentration in soil (mg/kg) = Chemical-specific
 IR - Ingestion rate (mg soil/day) = 480 [EPA, 1997]
 FI - Fraction ingested from source (unitless) = 1
 EF - Exposure frequency (days/year) = 60 [professional judgment]
 ED - Exposure Duration (years) = 1 [EPA, 1991]
 CF - Conversion Factor (kg/mg) = 1.00E-06
 BW - Body weight (kg) = 70 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 365
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	28	3.2E-05	1.0E-01	3.2E-04	4.5E-07	NA	NA
Benzene	0.75	8.5E-07	3.0E-03	2.8E-04	1.2E-08	2.9E-02	3.5E-10
2-Butanone	3.8	4.3E-06	6.0E-01	7.1E-06	6.1E-08	NA	NA
4-Methyl-2-pentanone	32	3.6E-05	8.0E-02	4.5E-04	5.2E-07	NA	NA
Bis(2-ethylhexyl)phthalate	0.084	9.5E-08	2.0E-02	4.7E-06	1.4E-09	1.4E-02	1.9E-11
2-Methylphenol	1	1.1E-06	5.0E-02	2.3E-05	1.6E-08	NA	NA
4-Methylphenol	0.59	6.7E-07	5.0E-03	1.3E-04	9.5E-09	NA	NA
Naphthalene	0.076	8.6E-08	2.0E-02	4.3E-06	1.2E-09	NA	NA
Phenol	47	5.3E-05	6.0E-01	8.8E-05	7.6E-07	NA	NA
Cadmium (as food)	0.2	2.3E-07	1.0E-03	2.3E-04	3.2E-09	NA	NA
Chromium (as Cr+3)	14.7	1.7E-05	1.5E+00	1.1E-05	2.4E-07	NA	NA
Chromium (as Cr+6)	2.4	2.7E-06	3.0E-03	9.0E-04	3.9E-08	NA	NA
Copper	27.3	3.1E-05	4.0E-02	7.7E-04	4.4E-07	NA	NA
Nickel	33.3	3.8E-05	2.0E-02	1.9E-03	5.4E-07	NA	NA
Zinc	81.3	9.2E-05	3.0E-01	3.1E-04	1.3E-06	NA	NA

TOTAL HI = 5.4E-03 TOTAL CANCER RISK = 3.7E-10

Table 5-17
Dermal Exposure to Off-Site Soil by Construction Workers
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_s \cdot SA \cdot AF \cdot ABS \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

Cs = Concentration in soil (mg/kg) =	Chemical-specific
SA - Skin surface area available for exposure (cm ² /day) =	5,300 [EPA, 1992]
AF - Soil adherence factor (unitless) =	0.6
ABS - Absorption factor (unitless) =	(10% for organics, 1% for inorganics)
EF - Exposure frequency (days/year) =	60 [professional judgment]
ED - Exposure Duration (years) =	1 [EPA, 1991]
CF - Conversion Factor (kg/mg) =	1.00E-06
BW - Body weight (kg) =	70 [EPA, 1991]
ATn - Averaging time noncarcinogenic (days) =	365
ATc - Averaging time carcinogenic (days) =	25,550

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	28	2.1E-05	8.3E-02	2.5E-04	3.0E-07	NA	NA
Benzene	0.75	5.6E-07	3.0E-03	1.9E-04	8.0E-09	2.9E-02	2.3E-10
2-Butanone	3.8	2.8E-06	6.0E-01	4.7E-06	4.1E-08	NA	NA
4-Methyl-2-pentanone	32	2.4E-05	8.0E-02	3.0E-04	3.4E-07	NA	NA
Bis(2-ethylhexyl)phthalate	0.084	6.3E-08	1.1E-02	5.7E-06	9.0E-10	2.6E-02	2.3E-11
2-Methylphenol	1	7.5E-07	4.0E-02	1.9E-05	1.1E-08	NA	NA
4-Methylphenol	0.99	4.4E-07	4.0E-03	1.1E-04	6.3E-09	NA	NA
Naphthalene	0.076	5.7E-08	2.0E-02	2.8E-06	8.1E-10	NA	NA
Phenol	47	3.5E-05	5.4E-01	6.5E-05	5.0E-07	NA	NA
Cadmium (as food)	0.2	1.5E-08	2.5E-05	6.0E-04	2.1E-10	NA	NA
Chromium (as Cr+3)	14.7	1.1E-06	6.0E-02	1.8E-05	1.6E-08	NA	NA
Chromium (as Cr+6)	2.4	1.8E-07	1.2E-04	1.5E-03	2.6E-09	NA	NA
Copper	27.3	2.0E-06	2.4E-02	8.5E-05	2.9E-08	NA	NA
Nickel	33.3	2.5E-06	1.0E-03	2.5E-03	3.6E-08	NA	NA
Zinc	81.3	6.1E-06	1.5E-01	4.0E-05	8.7E-08	NA	NA

TOTAL HI = 5.7E-03 TOTAL CANCER RISK = 2.5E-10

Table 5-18
Inhalation of Airborne Chemicals from Off-Site Soil by Construction Worker
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{\text{Ca} \cdot \text{IR} \cdot \text{ET} \cdot \text{EF} \cdot \text{ED} \cdot (1/\text{VF} + 1/\text{PEF})}{\text{BW} \cdot \text{AT}}$$

Ca = Concentration in air (mg/m³) = Chemical-specific
 IR - Inhalation rate (m³/hour) = 2.5 [EPA, 1997]
 ET - Exposure time (hours/day) = 8
 EF - Exposure frequency (days/year) = 60 [professional judgment]
 VF - Volatilization Factor (m³/kg) = Chemical-specific
 PEF - Particulate Emission Factor (m³/kg) = 1.32E+09 [EPA, 1991]
 ED - Exposure Duration (years) = 1
 BW - Body weight (kg) = 70 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 365
 ATc - Averaging time carcinogenic (days) = 25550

Constituent	Soil EPC (mg/kg)	Volatilization Factor (m ³ /kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	28	2.95E+03	4.5E-04	NA	NA	6.4E-06	NA	NA
Benzene	0.75	2.11E+04	1.7E-06	1.7E-03	9.8E-04	2.4E-08	2.9E-02	6.9E-10
2-Butanone	3.8	8.20E+03	2.2E-05	2.9E-01	7.6E-05	3.1E-07	NA	NA
4-Methyl-2-pentanone	32	1.67E+03	9.0E-04	2.0E-02	4.5E-02	1.3E-05	NA	NA
Bis(2-ethylhexyl)phthalate	0.084	NA	3.0E-12	NA	NA	4.3E-14	1.4E-02	6.0E-16
2-Methylphenol	1	NA	3.6E-11	NA	NA	5.1E-13	NA	NA
4-Methylphenol	0.59	NA	2.1E-11	NA	NA	3.0E-13	NA	NA
Naphthalene	0.076	NA	2.7E-12	9.0E-04	3.0E-09	3.9E-14	NA	NA
Phenol	47	NA	1.7E-09	NA	NA	2.4E-11	NA	NA
Cadmium (as food)	0.2	NA	7.1E-12	NA	NA	1.0E-13	6.3E+00	6.4E-13
Chromium (as Cr+3)	14.7	NA	5.2E-10	5.7E-07	9.2E-04	7.5E-12	NA	NA
Chromium (as Cr+6)	2.4	NA	8.5E-11	3.0E-05	2.8E-06	1.2E-12	4.1E+01	5.0E-11
Copper	27.3	NA	9.7E-10	NA	NA	1.4E-11	NA	NA
Nickel	33.3	NA	1.2E-09	NA	NA	1.7E-11	NA	NA
Zinc	81.3	NA	2.9E-09	NA	NA	4.1E-11	NA	NA

TOTAL HI = 4.7E-02 TOTAL CANCER RISK = 7.4E-10

Table 5-19
Ingestion of Off-Site Soil by Adult Resident
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_s \cdot IR \cdot FI \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

C_s = Concentration in soil (mg/kg) = Chemical-specific
 IR - Ingestion rate (mg soil/day) = 100 [EPA, 1991]
 FI - Fraction ingested from source (unitless) = 1
 EF - Exposure frequency (days/year) = 350 [EPA, 1991]
 ED - Exposure Duration (years) = 24 [EPA, 1991]
 CF - Conversion Factor (kg/mg) = 1.00E-06
 BW - Body weight (kg) = 70 [EPA, 1991]
 AT_n - Averaging time noncarcinogenic (days) = 8,760
 AT_c - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	28	3.8E-05	1.0E-01	3.8E-04	1.3E-05	NA	NA
Benzene	0.75	1.0E-06	3.0E-03	3.4E-04	3.5E-07	2.9E-02	1.0E-08
2-Butanone	3.8	5.2E-06	6.0E-01	8.7E-06	1.8E-06	NA	NA
4-Methyl-2-pentanone	32	4.4E-05	8.0E-02	5.5E-04	1.5E-05	NA	NA
Bis(2-ethylhexyl)phthalate	0.084	1.2E-07	2.0E-02	5.8E-06	3.9E-08	1.4E-02	5.5E-10
2-Methylphenol	1	1.4E-06	5.0E-02	2.7E-05	4.7E-07	NA	NA
4-Methylphenol	0.59	8.1E-07	5.0E-03	1.6E-04	2.8E-07	NA	NA
Naphthalene	0.076	1.0E-07	2.0E-02	5.2E-06	3.6E-08	NA	NA
Phenol	47	6.4E-05	6.0E-01	1.1E-04	2.2E-05	NA	NA
Cadmium (as food)	0.2	2.7E-07	1.0E-03	2.7E-04	9.4E-08	NA	NA
Chromium (as Cr+3)	14.7	2.0E-05	1.5E+00	1.3E-05	6.9E-06	NA	NA
Chromium (as Cr+6)	2.4	3.3E-06	3.0E-03	1.1E-03	1.1E-06	NA	NA
Copper	27.3	3.7E-05	4.0E-02	9.3E-04	1.3E-05	NA	NA
Nickel	33.3	4.6E-05	2.0E-02	2.3E-03	1.6E-05	NA	NA
Zinc	81.3	1.1E-04	3.0E-01	3.7E-04	3.8E-05	NA	NA

TOTAL HI = 6.6E-03 TOTAL CANCER RISK = 1.1E-08

Table 5-20
Dermal Exposure to Off-Site Soil by Adult Resident
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_s \cdot SA \cdot AF \cdot ABS \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

Cs = Concentration in soil (mg/kg) =	Chemical-specific
SA - Skin surface area available for exposure (cm ² /day) =	5,300 [EPA, 1997]
AF - Soil adherence factor (unitless) =	0.6
ABS - Absorption factor (unitless) =	(10% for organics, 1% for inorganics)
EF - Exposure frequency (days/year) =	350 [EPA, 1991]
ED - Exposure Duration (years) =	24 [EPA, 1991]
CF - Conversion Factor (kg/mg) =	1.00E-06
BW - Body weight (kg) =	70 [EPA, 1991]
ATn - Averaging time noncarcinogenic (days) =	8,760
ATc - Averaging time carcinogenic (days) =	25,550

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	28	1.2E-04	8.3E-02	1.5E-03	4.2E-05	NA	NA
Benzene	0.75	3.3E-06	3.0E-03	1.1E-03	1.1E-06	2.9E-02	3.2E-08
2-Butanone	3.8	1.7E-05	6.0E-01	2.8E-05	5.7E-06	NA	NA
4-Methyl-2-pentanone	32	1.4E-04	8.0E-02	1.7E-03	4.8E-05	NA	NA
Bis(2-ethylhexyl)phthalate	0.084	3.7E-07	1.1E-02	3.3E-05	1.3E-07	2.6E-02	3.2E-09
2-Methylphenol	1	4.4E-06	4.0E-02	1.1E-04	1.5E-06	NA	NA
4-Methylphenol	0.59	2.6E-06	4.0E-03	6.4E-04	8.8E-07	NA	NA
Naphthalene	0.076	3.3E-07	2.0E-02	1.7E-05	1.1E-07	NA	NA
Phenol	47	2.0E-04	5.4E-01	3.8E-04	7.0E-05	NA	NA
Cadmium (as food)	0.2	8.7E-08	2.5E-05	3.5E-03	3.0E-08	NA	NA
Chromium (as Cr+3)	14.7	6.4E-06	6.0E-02	1.1E-04	2.2E-06	NA	NA
Chromium (as Cr+6)	2.4	1.0E-06	1.2E-04	8.7E-03	3.6E-07	NA	NA
Copper	27.3	1.2E-05	2.4E-02	5.0E-04	4.1E-06	NA	NA
Nickel	33.3	1.5E-05	1.0E-03	1.5E-02	5.0E-06	NA	NA
Zinc	81.3	3.5E-05	1.5E-01	2.4E-04	1.2E-05	NA	NA

TOTAL HI = 3.3E-02 TOTAL CANCER RISK = 3.6E-08

Table 5-21

*Inhalation of Airborne Chemicals from Off-Site Soil by Adult Resident
Greiner's Lagoon Site
Fremont, Ohio*

$$\text{Intake (mg/kg-day)} = \frac{\text{Ca} \cdot \text{IR} \cdot \text{ET} \cdot \text{EF} \cdot \text{ED} \cdot (1/\text{VF} + 1/\text{PEF})}{\text{BW} \cdot \text{AT}}$$

Ca = Concentration in air (mg/m³) = Chemical-specific
 IR - Inhalation rate (m³/hour) = 0.552 [EPA, 1997]
 ET - Exposure time (hours/day) = 24
 EF - Exposure frequency (days/year) = 350 [EPA, 1991]
 VF - Volatilization Factor (m³/kg) = Chemical-specific
 PEF - Particulate Emission Factor (m³/kg) = 1.32E+09 [EPA, 1991]
 ED - Exposure Duration (years) = 24 [EPA, 1991]
 BW - Body weight (kg) = 70 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 8760
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Volatilization Factor (m ³ /kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	28	2.95E+03	1.7E-03	NA	NA	5.9E-04	NA	NA
Benzene	0.75	2.11E+04	6.5E-06	1.7E-03	3.8E-03	2.2E-06	2.9E-02	6.4E-08
2-Butanone	3.8	8.20E+03	8.4E-05	2.9E-01	2.9E-04	2.9E-05	NA	NA
4-Methyl-2-pentanone	32	1.67E+03	3.5E-03	2.0E-02	1.7E-01	1.2E-03	NA	NA
Bis(2-ethylhexyl)phthalate	0.084	NA	1.2E-11	NA	NA	4.0E-12	1.4E-02	5.5E-14
2-Methylphenol	1	NA	1.4E-10	NA	NA	4.7E-11	NA	NA
4-Methylphenol	0.59	NA	8.1E-11	NA	NA	2.8E-11	NA	NA
Naphthalene	0.076	NA	1.0E-11	9.0E-04	1.2E-08	3.6E-12	NA	NA
Phenol	47	NA	6.5E-09	NA	NA	2.2E-09	NA	NA
Cadmium	0.2	NA	2.7E-11	NA	NA	9.4E-12	6.3E+00	5.9E-11
Chromium (as Cr+3)	14.7	NA	2.0E-09	5.7E-07	3.5E-03	6.9E-10	NA	NA
Chromium (as Cr+6)	2.4	NA	3.3E-10	3.0E-05	1.1E-05	1.1E-10	4.1E+01	4.6E-09
Copper	27.3	NA	3.8E-09	NA	NA	1.3E-09	NA	NA
Nickel	33.3	NA	4.6E-09	NA	NA	1.6E-09	NA	NA
Zinc	81.3	NA	1.1E-08	NA	NA	3.8E-09	NA	NA

TOTAL HI = 1.8E-01

TOTAL CANCER RISK = 6.9E-08

Table 5-22
Ingestion of Off-Site Soil by Child Resident
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{\text{Cs} \cdot \text{IR} \cdot \text{FI} \cdot \text{EF} \cdot \text{ED} \cdot \text{CF}}{\text{BW} \cdot \text{AT}}$$

Cs = Concentration in soil (mg/kg) = Chemical-specific
 IR - Ingestion rate (mg soil/day) = 200 [EPA, 1991]
 FI - Fraction ingested from source (unitless) = 1
 EF - Exposure frequency (days/year) = 350 [EPA, 1991]
 ED - Exposure Duration (years) = 6 [EPA, 1991]
 CF - Conversion Factor (kg/mg) = 1.00E-06
 BW - Body weight (kg) = 15 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 2,190
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	28	3.6E-04	1.0E-01	3.6E-03	3.1E-05	NA	NA
Benzene	0.75	9.6E-06	3.0E-03	3.2E-03	8.2E-07	2.9E-02	2.4E-08
2-Butanone	3.8	4.9E-05	6.0E-01	8.1E-05	4.2E-06	NA	NA
4-Methyl-2-pentanone	32	4.1E-04	8.0E-02	5.1E-03	3.5E-05	NA	NA
Bis(2-ethylhexyl)phthalate	0.084	1.1E-06	2.0E-02	5.4E-05	9.2E-08	1.4E-02	1.3E-09
2-Methylphenol	1	1.3E-05	5.0E-02	2.6E-04	1.1E-06	NA	NA
4-Methylphenol	0.59	7.5E-06	5.0E-03	1.5E-03	6.5E-07	NA	NA
Naphthalene	0.076	9.7E-07	2.0E-02	4.9E-05	8.3E-08	NA	NA
Phenol	47	6.0E-04	6.0E-01	1.0E-03	5.2E-05	NA	NA
Cadmium (as food)	0.2	2.6E-06	1.0E-03	2.6E-03	2.2E-07	NA	NA
Chromium (as Cr+3)	14.7	1.9E-04	1.5E+00	1.3E-04	1.6E-05	NA	NA
Chromium (as Cr+6)	2.4	3.1E-05	3.0E-03	1.0E-02	2.6E-06	NA	NA
Copper	27.3	3.5E-04	4.0E-02	8.7E-03	3.0E-05	NA	NA
Nickel	33.3	4.3E-04	2.0E-02	2.1E-02	3.6E-05	NA	NA
Zinc	81.3	1.0E-03	3.0E-01	3.5E-03	8.9E-05	NA	NA

TOTAL HI = 6.1E-02 TOTAL CANCER RISK = 2.5E-08

Table 5-23
Dermal Exposure to Off-Site Soil by Child Resident
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_s \cdot SA \cdot AF \cdot ABS \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

Cs = Concentration in soil (mg/kg) = Chemical-specific
 SA - Skin surface area available for exposure (cm²/day) = 2,000 [EPA, 1997]
 AF - Soil adherence factor (unitless) = 0.6
 ABS - Absorption factor (unitless) = (10% for organics, 1% for inorganics)
 EF - Exposure frequency (days/year) = 350 [EPA, 1991]
 ED - Exposure Duration (years) = 6 [EPA, 1991]
 CF - Conversion Factor (kg/mg) = 1.00E-06
 BW - Body weight (kg) = 15 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 2,190
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	28	2.1E-04	8.3E-02	2.6E-03	1.8E-05	NA	NA
Benzene	0.75	5.8E-06	3.0E-03	1.9E-03	4.9E-07	2.9E-02	1.4E-08
2-Butanone	3.8	2.9E-05	6.0E-01	4.9E-05	2.5E-06	NA	NA
4-Methyl-2-pentanone	32	2.5E-04	8.0E-02	3.1E-03	2.1E-05	NA	NA
Bis(2-ethylhexyl)phthalate	0.084	6.4E-07	1.1E-02	5.9E-05	5.5E-08	2.6E-02	1.4E-09
2-Methylphenol	1	7.7E-06	4.0E-02	1.9E-04	6.6E-07	NA	NA
4-Methylphenol	0.59	4.5E-06	4.0E-03	1.1E-03	3.9E-07	NA	NA
Naphthalene	0.076	5.8E-07	2.0E-02	2.9E-05	5.0E-08	NA	NA
Phenol	47	3.6E-04	5.4E-01	6.7E-04	3.1E-05	NA	NA
Cadmium (as food)	0.2	1.5E-07	2.5E-05	6.1E-03	1.3E-08	NA	NA
Chromium (as Cr+3)	14.7	1.1E-05	6.0E-02	1.9E-04	9.7E-07	NA	NA
Chromium (as Cr+6)	2.4	1.8E-06	1.2E-04	1.5E-02	1.6E-07	NA	NA
Copper	27.3	2.1E-05	2.4E-02	8.7E-04	1.8E-06	NA	NA
Nickel	33.3	2.6E-05	1.0E-03	2.6E-02	2.2E-06	NA	NA
Zinc	81.3	6.2E-05	1.5E-01	4.2E-04	5.3E-06	NA	NA
		TOTAL HI =		5.8E-02	TOTAL CANCER RISK =		1.6E-06

Table 5-24
Inhalation of Airborne Chemicals from Off-Site Soil by Child Resident
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{\text{Ca} \cdot \text{IR} \cdot \text{ET} \cdot \text{EF} \cdot \text{ED} \cdot (1/\text{VF} + 1/\text{PEF})}{\text{BW} \cdot \text{AT}}$$

Ca = Concentration in air (mg/m³) = Chemical-specific
 IR - Inhalation rate (m³/hour) = 0.417 [EPA, 1997]
 ET - Exposure time (hours/day) = 24
 EF - Exposure frequency (days/year) = 350 [EPA, 1991]
 VF - Volatilization Factor (m³/kg) = Chemical-specific
 PEF - Particulate Emission Factor (m³/kg) = 1.32E+09 [EPA, 1991]
 ED - Exposure Duration (years) = 6 [EPA, 1991]
 BW - Body weight (kg) = 15 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 2,190
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Volatilization Factor (m ³ /kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	28	2.95E+03	6.1E-03	NA	NA	5.2E-04	NA	NA
Benzene	0.75	2.11E+04	2.3E-05	1.7E-03	1.3E-02	1.9E-06	2.9E-02	5.7E-08
2-Butanone	3.8	8.20E+03	3.0E-04	2.9E-01	1.0E-03	2.5E-05	NA	NA
4-Methyl-2-pentanone	32	1.67E+03	1.2E-02	2.0E-02	6.1E-01	1.1E-03	NA	NA
Bis(2-ethylhexyl)phthalate	0.084	NA	4.1E-11	NA	NA	3.5E-12	1.4E-02	4.9E-14
2-Methylphenol	1	NA	4.8E-10	NA	NA	4.2E-11	NA	NA
4-Methylphenol	0.59	NA	2.9E-10	NA	NA	2.5E-11	NA	NA
Naphthalene	0.076	NA	3.7E-11	9.0E-04	4.1E-08	3.2E-12	NA	NA
Phenol	47	NA	2.3E-08	NA	NA	2.0E-09	NA	NA
Cadmium	0.2	NA	9.7E-11	NA	NA	8.3E-12	6.3E+00	5.2E-11
Chromium (as Cr+3)	14.7	NA	7.1E-09	5.7E-07	1.2E-02	6.1E-10	NA	NA
Chromium (as Cr+6)	2.4	NA	1.2E-09	3.0E-05	3.9E-05	1.0E-10	4.1E+01	4.1E-09
Copper	27.3	NA	1.3E-08	NA	NA	1.1E-09	NA	NA
Nickel	33.3	NA	1.6E-08	NA	NA	1.4E-09	NA	NA
Zinc	81.3	NA	3.9E-08	NA	NA	3.4E-09	NA	NA

TOTAL HI = 6.4E-01 TOTAL CANCER RISK = 6.1E-08

Table 5-25
Ingestion of On-Site Soil by Construction Worker
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{\text{Cs} \cdot \text{IR} \cdot \text{FI} \cdot \text{EF} \cdot \text{ED} \cdot \text{CF}}{\text{BW} \cdot \text{AT}}$$

Cs = Concentration in soil (mg/kg) = Chemical-specific
 IR - Ingestion rate (mg soil/day) = 480 [EPA, 1997]
 FI - Fraction ingested from source (unitless) = 1
 EF - Exposure frequency (days/year) = 60 [professional judgment]
 ED - Exposure Duration (years) = 1 [EPA, 1991]
 CF - Conversion Factor (kg/mg) = 1.00E-06
 BW - Body weight (kg) = 70 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 365
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	32	3.6E-05	1.0E-01	3.6E-04	5.2E-07	NA	NA
Benzene	27	3.0E-05	3.0E-03	1.0E-02	4.3E-07	2.9E-02	1.3E-08
2-Butanone	1.9	2.1E-06	6.0E-01	3.6E-06	3.1E-08	NA	NA
Ethylbenzene	110	1.2E-04	1.0E-01	1.2E-03	1.8E-06	NA	NA
2-Hexanone	0.0053	6.0E-09	8.0E-02	7.5E-08	8.5E-11	NA	NA
4-Methyl-2-pentanone	140	1.6E-04	8.0E-02	2.0E-03	2.3E-06	NA	NA
Styrene	3.8	4.3E-06	2.0E-01	2.1E-05	6.1E-08	NA	NA
1,1,2,2-Tetrachloroethane	0.47	5.3E-07	6.0E-02	8.8E-06	7.6E-09	2.0E-01	1.5E-09
Toluene	330	3.7E-04	2.0E-01	1.9E-03	5.3E-06	NA	NA
Trichloroethene	9.5	1.1E-05	6.0E-03	1.8E-03	1.5E-07	1.1E-02	1.7E-09
Xylenes	520	5.9E-04	2.0E+00	2.9E-04	8.4E-06	NA	NA
Bis(2-ethylhexyl)phthalate	4000	4.5E-03	2.0E-02	2.3E-01	6.4E-05	1.4E-02	9.0E-07
Butyl benzyl phthalate	86	9.7E-05	2.0E-01	4.8E-04	1.4E-06	NA	NA
2-Chlorophenol	0.13	1.5E-07	5.0E-03	2.9E-05	2.1E-09	NA	NA
1,2-Dichlorobenzene	230	2.6E-04	9.0E-02	2.9E-03	3.7E-06	NA	NA
1,4-Dichlorobenzene	91	1.0E-04	3.0E-02	3.4E-03	1.5E-06	2.4E-02	3.5E-08
2,4-Dichlorobenzene	1.2	1.4E-06	2.0E-02	6.8E-05	1.9E-08	NA	NA
Di-n-butyl phthalate	36	4.1E-05	1.0E-01	4.1E-04	5.8E-07	NA	NA
Isophorone	0.1	1.1E-07	2.0E-01	5.6E-07	1.6E-09	9.5E-04	1.5E-12
2-Methylnaphthalene	130	1.5E-04	2.0E-02	7.3E-03	2.1E-06	NA	NA
2-Methylphenol	1.9	2.1E-06	5.0E-02	4.3E-05	3.1E-08	NA	NA
4-Methylphenol	2	2.3E-06	5.0E-03	4.5E-04	3.2E-08	NA	NA
Naphthalene	86	9.7E-05	2.0E-02	4.8E-03	1.4E-06	NA	NA
Phenanthrene	0.52	5.9E-07	3.0E-02	2.0E-05	8.4E-09	NA	NA
Phenol	430	4.8E-04	6.0E-01	8.1E-04	6.9E-06	NA	NA
Pyrene	0.12	1.4E-07	3.0E-02	4.5E-06	1.9E-09	NA	NA
1,2,4-Trichlorobenzene	350	3.9E-04	1.0E-02	3.9E-02	5.6E-06	NA	NA
Aroclor 1254	38	4.3E-05	2.0E-05	2.1E+00	6.1E-07	2.0E+00	1.2E-06
Endrin ketone	0.63	7.1E-07	3.0E-04	2.4E-03	1.0E-08	NA	NA
Antimony	1.7	1.9E-06	4.0E-04	4.8E-03	2.7E-08	NA	NA
Cadmium (as food)	43.7	4.9E-05	1.0E-03	4.9E-02	7.0E-07	NA	NA
Chromium (as Cr+3)	31.5	3.6E-05	1.5E+00	2.4E-05	5.1E-07	NA	NA
Chromium (as Cr+6)	5.24	5.9E-06	3.0E-03	2.0E-03	8.4E-08	NA	NA
Copper	52.5	5.9E-05	4.0E-02	1.5E-03	8.5E-07	NA	NA
Mercury	0.5	5.6E-07	3.0E-04	1.9E-03	8.1E-09	NA	NA
Nickel	23.6	2.7E-05	2.0E-02	1.3E-03	3.8E-07	NA	NA
Selenium	0.9	1.0E-06	5.0E-03	2.0E-04	1.4E-08	NA	NA
Zinc	1105.3	1.2E-03	3.0E-01	4.2E-03	1.8E-05	NA	NA

TOTAL HI = 2.5E+00 TOTAL CANCER RISK = 2.2E-06

Table 5-26
Dermal Exposure to On-Site Soil by Construction Workers
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{\text{Cs} * \text{SA} * \text{AF} * \text{ABS} * \text{EF} * \text{ED} * \text{CF}}{\text{BW} * \text{AT}}$$

Cs = Concentration in soil (mg/kg) = Chemical-specific
SA - Skin surface area available for exposure (cm²/day) = 5,300 [EPA, 1997]
AF - Soil adherence factor (unitless) = 0.6
ABS - Absorption factor (unitless) = (10% for organics, 1% for inorganics)
EF - Exposure frequency (days/year) = 60 [professional judgment]
ED - Exposure Duration (years) = 1 [EPA, 1991]
CF - Conversion Factor (kg/mg) = 1.00E-06
BW - Body weight (kg) = 70 [EPA, 1991]
ATn - Averaging time noncarcinogenic (days) = 365
ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	32	2.4E-05	8.3E-02	2.9E-04	3.4E-07	NA	NA
Benzene	27	2.0E-05	3.0E-03	6.7E-03	2.9E-07	2.9E-02	8.4E-09
2-Butanone	1.9	1.4E-06	6.0E-01	2.4E-06	2.0E-08	NA	NA
Ethylbenzene	110	8.2E-05	9.2E-02	8.9E-04	1.2E-06	NA	NA
2-Hexanone	0.0053	4.0E-09	8.0E-02	4.9E-08	5.7E-11	NA	NA
4-Methyl-2-pentanone	140	1.0E-04	8.0E-02	1.3E-03	1.5E-06	NA	NA
Styrene	3.8	2.8E-06	1.8E-01	1.6E-05	4.1E-08	NA	NA
1,1,2,2-Tetrachloroethane	0.47	3.5E-07	6.0E-02	5.8E-06	5.0E-09	2.0E-01	1.0E-09
Toluene	330	2.5E-04	2.0E-01	1.2E-03	3.5E-06	NA	NA
Trichloroethene	9.5	7.1E-06	6.0E-03	1.2E-03	1.0E-07	1.1E-02	1.1E-09
Xylenes	520	3.9E-04	1.8E+00	2.1E-04	5.5E-06	NA	NA
Bis(2-ethylhexyl)phthalate	4000	3.0E-03	1.1E-02	2.7E-01	4.3E-05	2.6E-02	1.1E-06
Butyl benzyl phthalate	86	6.4E-05	1.8E-01	3.6E-04	9.2E-07	NA	NA
2-Chlorophenol	0.13	9.7E-08	5.0E-03	1.9E-05	1.4E-09	NA	NA
1,2-Dichlorobenzene	230	1.7E-04	9.0E-02	1.9E-03	2.5E-06	NA	NA
1,4-Dichlorobenzene	91	6.8E-05	3.0E-02	2.3E-03	9.7E-07	2.4E-02	2.3E-08
2,4-Dichlorobenzene	1.2	9.0E-07	2.0E-02	4.5E-05	1.3E-08	NA	NA
Di-n-butyl phthalate	36	2.7E-05	8.5E-02	3.2E-04	3.8E-07	NA	NA
Isophorone	0.1	7.5E-08	1.0E-01	7.5E-07	1.1E-09	1.9E-03	2.0E-12
2-Methylnaphthalene	130	9.7E-05	2.0E-02	4.9E-03	1.4E-06	NA	NA
2-Methylphenol	1.9	1.4E-06	4.0E-02	3.5E-05	2.0E-08	NA	NA
4-Methylphenol	2	1.5E-06	4.0E-03	3.7E-04	2.1E-08	NA	NA
Naphthalene	86	6.4E-05	2.0E-02	3.2E-03	9.2E-07	NA	NA
Phenanthrene	0.52	3.9E-07	1.8E-01	2.2E-06	5.5E-09	NA	NA
Phenol	430	3.2E-04	5.4E-01	5.9E-04	4.6E-06	NA	NA
Pyrene	0.12	9.0E-08	2.4E-02	3.7E-06	1.3E-09	NA	NA
1,2,4-Trichlorobenzene	350	2.6E-04	3.0E-03	8.7E-02	3.7E-06	NA	NA
Aroclor 1254	38	2.8E-05	1.9E-05	1.5E+00	4.1E-07	2.1E+00	8.6E-07
Endrin ketone	0.63	4.7E-07	1.5E-04	3.1E-03	6.7E-09	NA	NA
Antimony	1.7	1.3E-07	4.0E-05	3.2E-03	1.8E-09	NA	NA
Cadmium (as food)	43.7	3.3E-06	2.5E-05	1.3E-01	4.7E-08	NA	NA
Chromium (as Cr+3)	31.5	2.4E-06	6.0E-02	3.9E-05	3.4E-08	NA	NA
Chromium (as Cr+6)	5.24	3.9E-07	1.2E-04	3.3E-03	5.6E-09	NA	NA
Copper	52.5	3.9E-06	2.4E-02	1.6E-04	5.6E-08	NA	NA
Mercury	0.5	3.7E-08	4.5E-05	8.3E-04	5.3E-10	NA	NA
Nickel	23.6	1.8E-06	1.0E-03	1.8E-03	2.5E-08	NA	NA
Selenium	0.9	6.7E-08	4.5E-03	1.5E-05	9.6E-10	NA	NA
Zinc	1105.3	8.3E-05	1.5E-01	5.5E-04	1.2E-06	NA	NA

TOTAL HI = 2.0E+00

TOTAL CANCER RISK = 2.0E-06

Table 5-27

*Inhalation of Airborne Chemicals from On-Site Soils by Construction Workers
Greiner's Lagoon Site
Fremont, Ohio*

$$\text{Intake (mg/kg-day)} = \frac{\text{Ca} \cdot \text{IR} \cdot \text{ET} \cdot \text{EF} \cdot \text{ED} \cdot (1/\text{VF} + 1/\text{PEF})}{\text{BW} \cdot \text{AT}}$$

Ca = Concentration in air (mg/m³) = Chemical-specific
 IR - Inhalation rate (m³/hour) = 2.5 [EPA, 1997]
 ET - Exposure time (hours/day) = 8
 EF - Exposure frequency (days/year) = 60 [professional judgment]
 VF - Volatilization Factor (m³/kg) = Chemical-specific
 PEF - Particulate Emission Factor (m³/kg) = 1.32E+09 [EPA, 1991]
 ED - Exposure Duration (years) = 1
 BW - Body weight (kg) = 70 [EPA, 1991]
 ATn - Averaging time noncarcinogenic (days) = 365
 ATc - Averaging time carcinogenic (days) = 25550

Constituent	Soil EPC (mg/kg)	Volatilization Factor (m ³ /kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	32	2.95E+03	5.1E-04	NA	NA	7.3E-06	NA	NA
Benzene	27	2.11E+04	6.0E-05	1.7E-03	3.5E-02	8.6E-07	2.9E-02	2.5E-08
2-Butanone	1.9	8.20E+03	1.1E-05	2.9E-01	3.8E-05	1.6E-07	NA	NA
Ethylbenzene	110	2.42E+03	2.1E-03	2.9E-01	7.5E-03	3.0E-05	NA	NA
2-Hexanone	0.0053	2.81E+03	8.9E-08	2.3E-02	3.9E-06	1.3E-09	NA	NA
4-Methyl-2-pentanone	140	1.67E+03	3.9E-03	2.0E-02	2.0E-01	5.6E-05	NA	NA
Styrene	3.8	6.11E+03	2.9E-05	2.9E-01	1.0E-04	4.2E-07	NA	NA
1,1,2,2-Tetrachloroethane	0.47	6.04E+03	3.7E-06	NA	NA	5.2E-08	2.0E-01	1.1E-08
Toluene	330	1.75E+03	8.9E-03	1.1E-01	7.8E-02	1.3E-04	NA	NA
Trichloroethene	9.5	1.42E+03	3.1E-04	NA	NA	4.5E-06	6.0E-03	2.7E-08
Xylenes	520	2.51E+03	9.7E-03	NA	NA	1.4E-04	NA	NA
Bis(2-ethylhexyl)phthalate	4000	NA	1.4E-07	NA	NA	2.0E-09	1.4E-02	2.8E-11
Butyl benzyl phthalate	86	NA	3.1E-09	NA	NA	4.4E-11	NA	NA
2-Chlorophenol	0.13	NA	4.6E-12	NA	NA	6.6E-14	NA	NA
1,2-Dichlorobenzene	230	NA	8.2E-09	9.0E-03	9.1E-07	1.2E-10	NA	NA
1,4-Dichlorobenzene	91	NA	3.2E-09	2.3E-01	1.4E-08	4.6E-11	2.2E-02	1.0E-12
2,4-Dichlorobenzene	1.2	NA	4.3E-11	NA	NA	6.1E-13	NA	NA
Di-n-butyl phthalate	36	NA	1.3E-09	NA	NA	1.8E-11	NA	NA
Isophorone	0.1	NA	3.6E-12	NA	NA	5.1E-14	NA	NA
2-Methylisophthalene	130	NA	4.6E-09	NA	NA	6.6E-11	NA	NA
2-Methylphenol	1.9	NA	6.8E-11	NA	NA	9.7E-13	NA	NA
4-Methylphenol	2	NA	7.1E-11	NA	NA	1.0E-12	NA	NA
Naphthalene	86	NA	3.1E-09	9.0E-04	3.4E-06	4.4E-11	NA	NA
Phenanthrene	0.52	NA	1.9E-11	NA	NA	2.6E-13	NA	NA
Phenol	430	NA	1.5E-08	NA	NA	2.2E-10	NA	NA
Pyrene	0.12	NA	4.3E-12	NA	NA	6.1E-14	NA	NA
1,2,4-Trichlorobenzene	350	NA	1.2E-08	5.7E-02	2.2E-07	1.8E-10	NA	NA
Aroclor 1254	38	NA	1.4E-09	NA	NA	1.9E-11	2.0E+00	3.9E-11
Endrin ketone	0.63	NA	2.2E-11	NA	NA	3.2E-13	NA	NA
Antimony	1.7	NA	6.0E-11	NA	NA	8.6E-13	NA	NA
Cadmium	43.7	NA	1.6E-09	NA	NA	2.2E-11	6.3E+00	1.4E-10
Chromium (as Cr+3)	31.5	NA	1.1E-09	5.7E-07	2.0E-03	1.6E-11	NA	NA
Chromium (as Cr+6)	5.24	NA	1.9E-10	3.0E-05	6.2E-06	2.7E-12	4.1E+01	1.1E-10
Copper	52.5	NA	1.9E-09	NA	NA	2.7E-11	NA	NA
Mercury	0.5	NA	1.8E-11	8.6E-05	2.1E-07	2.5E-13	NA	NA
Nickel	23.6	NA	8.4E-10	NA	NA	1.2E-11	NA	NA
Selenium	0.9	NA	3.2E-11	NA	NA	4.6E-13	NA	NA
Zinc	1105.3	NA	3.9E-08	NA	NA	5.6E-10	NA	NA

TOTAL HI = 3.2E-01

TOTAL CANCER RISK = 6.3E-08

Table 5-28
Ingestion of On-Site Soil by Trespasser
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_s \cdot IR \cdot FI \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

C_s = Concentration in soil (mg/kg) = Chemical-specific
 IR - Ingestion rate (mg soil/day) = 100
 FI - Fraction ingested from source (unitless) = 1
 EF - Exposure frequency (days/year) = 12 [professional judgment]
 ED - Exposure Duration (years) = 6
 CF - Conversion Factor (kg/mg) = 1.00E-06
 BW - Body weight (kg) = 45
 ATn - Averaging time noncarcinogenic (days) = 2,190
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	32	2.3E-06	1.0E-01	2.3E-05	2.0E-07	NA	NA
Benzene	27	2.0E-06	3.0E-03	6.6E-04	1.7E-07	2.9E-02	4.9E-09
2-Butanone	1.9	1.4E-07	6.0E-01	2.3E-07	1.2E-08	NA	NA
Ethylbenzene	110	8.0E-06	1.0E-01	8.0E-05	6.9E-07	NA	NA
2-Hexanone	0.0053	3.9E-10	8.0E-02	4.8E-09	3.3E-11	NA	NA
4-Methyl-2-pentanone	140	1.0E-05	8.0E-02	1.3E-04	8.8E-07	NA	NA
Styrene	3.8	2.8E-07	2.0E-01	1.4E-06	2.4E-08	NA	NA
1,1,2,2-Tetrachloroethane	0.47	3.4E-08	6.0E-02	5.7E-07	2.9E-09	2.0E-01	5.9E-10
Toluene	330	2.4E-05	2.0E-01	1.2E-04	2.1E-06	NA	NA
Trichloroethene	9.5	6.9E-07	6.0E-03	1.2E-04	5.9E-08	1.1E-02	6.5E-10
Xylenes	520	3.8E-05	2.0E+00	1.9E-05	3.3E-06	NA	NA
Bis(2-ethylhexyl)phthalate	4000	2.9E-04	2.0E-02	1.5E-02	2.5E-05	1.4E-02	3.5E-07
Butyl benzyl phthalate	86	6.3E-06	2.0E-01	3.1E-05	5.4E-07	NA	NA
2-Chlorophenol	0.13	9.5E-09	5.0E-03	1.9E-06	8.1E-10	NA	NA
1,2-Dichlorobenzene	230	1.7E-05	9.0E-02	1.9E-04	1.4E-06	NA	NA
1,4-Dichlorobenzene	91	6.6E-06	3.0E-02	2.2E-04	5.7E-07	2.4E-02	1.4E-08
2,4-Dimethylphenol	1.2	8.8E-08	2.0E-02	4.4E-06	7.5E-09	NA	NA
Di-n-butyl phthalate	36	2.6E-06	1.0E-01	2.6E-05	2.3E-07	NA	NA
Isophorone	0.1	7.3E-09	2.0E-01	3.7E-08	6.3E-10	9.5E-04	5.9E-13
2-Methylnaphthalene	130	9.5E-06	2.0E-02	4.7E-04	8.1E-07	NA	NA
2-Methylphenol	1.9	1.4E-07	5.0E-02	2.8E-06	1.2E-08	NA	NA
4-Methylphenol	2	1.5E-07	5.0E-03	2.9E-05	1.3E-08	NA	NA
Naphthalene	86	6.3E-06	2.0E-02	3.1E-04	5.4E-07	NA	NA
Phenanthrene	0.52	3.8E-08	3.0E-02	1.3E-06	3.3E-09	NA	NA
Phenol	430	3.1E-05	6.0E-01	5.2E-05	2.7E-06	NA	NA
Pyrene	0.12	8.8E-09	3.0E-02	2.9E-07	7.5E-10	NA	NA
1,2,4-Trichlorobenzene	350	2.6E-05	1.0E-02	2.6E-03	2.2E-06	NA	NA
Aroclor 1254	38	2.8E-06	2.0E-05	1.4E-01	2.4E-07	2.0E+00	4.8E-07
Endrin ketone	0.63	4.6E-08	3.0E-04	1.5E-04	3.9E-09	NA	NA
Antimony	1.7	1.2E-07	4.0E-04	3.1E-04	1.1E-08	NA	NA
Cadmium (as food)	43.7	3.2E-06	1.0E-03	3.2E-03	2.7E-07	NA	NA
Chromium (as Cr+3)	31.5	2.3E-06	1.5E+00	1.5E-06	2.0E-07	NA	NA
Chromium (as Cr+6)	5.24	3.8E-07	3.0E-03	1.3E-04	3.3E-08	NA	NA
Copper	52.5	3.8E-06	4.0E-02	9.6E-05	3.3E-07	NA	NA
Mercury	0.5	3.7E-08	3.0E-04	1.2E-04	3.1E-09	NA	NA
Nickel	23.6	1.7E-06	2.0E-02	8.6E-05	1.5E-07	NA	NA
Selenium	0.9	6.6E-08	5.0E-03	1.3E-05	5.6E-09	NA	NA
Zinc	1105.3	8.1E-05	3.0E-01	2.7E-04	6.9E-06	NA	NA

TOTAL HI = 1.6E-01 TOTAL CANCER RISK = 8.5E-07

Table 5-29
Dermal Exposure to On-Site Soil by Trespassers
Greiner's Lagoon Site
Fremont, Ohio

Intake (mg/kg-day) =		$\frac{C_s \cdot SA \cdot AF \cdot ABS \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$					
		BW = AT					
Cs = Concentration in soil (mg/kg) =		Chemical-specific					
SA = Adolescent skin surface area (cm^2/day) =		3,500 [EPA, 1997]					
AF = Soil adherence factor (unitless) =		0.6					
ABS = Absorption factor (unitless) =		(10% for organics, 1% for inorganics)					
EF = Exposure frequency (days/year) =		12 [professional judgment]					
ED = Exposure Duration (years) =		6					
CF = Conversion Factor (kg/mg) =		1.00E-06					
BW = Body weight for adolescent (kg) =		45					
ATn = Averaging time noncarcinogenic (days) =		2,190					
ATc = Averaging time carcinogenic (days) =		25,550					

Constituent	Soil EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day)^-1	Cancer Risk
Acetone	32	4.9E-06	8.3E-02	5.9E-05	4.2E-07	NA	NA
Benzene	27	4.1E-06	3.0E-03	1.4E-03	3.6E-07	2.9E-02	1.0E-08
2-Butanone	1.9	2.9E-07	6.0E-01	4.9E-07	2.5E-08	NA	NA
Ethylbenzene	110	1.7E-05	9.2E-02	1.8E-04	1.4E-06	NA	NA
2-Hexanone	0.0053	8.1E-10	8.0E-02	1.0E-08	7.0E-11	NA	NA
4-Methyl-2-pentanone	140	2.1E-05	8.0E-02	2.7E-04	1.8E-06	NA	NA
Styrene	3.8	5.8E-07	1.8E-01	3.2E-06	5.0E-08	NA	NA
1,1,2,2-Tetrachloroethane	0.47	7.2E-08	6.0E-02	1.2E-06	6.2E-09	2.0E-01	1.2E-09
Toluene	330	5.1E-05	2.0E-01	2.5E-04	4.3E-06	NA	NA
Trichloroethene	9.5	1.5E-06	6.0E-03	2.4E-04	1.2E-07	1.1E-02	1.4E-09
Xylenes	520	8.0E-05	1.8E+00	4.3E-05	6.8E-06	NA	NA
Bis(2-ethylhexyl)phthalate	4000	6.1E-04	1.1E-02	5.6E-02	5.3E-05	2.6E-02	1.3E-06
Butyl benzyl phthalate	86	1.3E-05	1.8E-01	7.3E-05	1.1E-06	NA	NA
2-Chlorophenol	0.13	2.0E-08	5.0E-03	4.0E-06	1.7E-09	NA	NA
1,2-Dichlorobenzene	230	3.5E-05	9.0E-02	3.9E-04	3.0E-06	NA	NA
1,4-Dichlorobenzene	91	1.4E-05	3.0E-02	4.7E-04	1.2E-06	2.4E-02	2.9E-08
2,4-Dimethylphenol	1.2	1.8E-07	2.0E-02	9.2E-06	1.6E-08	NA	NA
Di-n-butyl phthalate	36	5.5E-06	8.5E-02	6.5E-05	4.7E-07	NA	NA
Isophorone	0.1	1.5E-08	1.0E-01	1.5E-07	1.3E-09	1.9E-03	2.5E-12
2-Methylnaphthalene	130	2.0E-05	2.0E-02	1.0E-03	1.7E-06	NA	NA
2-Methylphenol	1.9	2.9E-07	4.0E-02	7.3E-06	2.5E-08	NA	NA
4-Methylphenol	2	3.1E-07	4.0E-03	7.7E-05	2.6E-08	NA	NA
Naphthalene	86	1.3E-05	2.0E-02	6.6E-04	1.1E-06	NA	NA
Phenanthrene	0.52	8.0E-08	1.8E-01	4.4E-07	6.8E-09	NA	NA
Phenol	430	6.6E-05	5.4E-01	1.2E-04	5.7E-06	NA	NA
Pyrene	0.12	1.8E-08	2.4E-02	7.7E-07	1.6E-09	NA	NA
1,2,4-Trichlorobenzene	350	5.4E-05	3.0E-03	1.8E-02	4.6E-06	NA	NA
Aroclor 1254	38	5.8E-06	1.9E-05	3.1E-01	5.0E-07	2.1E+00	1.1E-06
Endrin ketone	0.63	9.7E-08	1.5E-04	6.4E-04	8.3E-09	NA	NA
Antimony	1.7	2.6E-08	4.0E-05	6.5E-04	2.2E-09	NA	NA
Cadmium (as food)	43.7	6.7E-07	2.5E-05	2.7E-02	5.7E-08	NA	NA
Chromium (as Cr+3)	31.5	4.8E-07	6.0E-02	8.1E-06	4.1E-08	NA	NA
Chromium (as Cr+6)	5.24	8.0E-08	1.2E-04	6.7E-04	6.9E-09	NA	NA
Copper	52.5	8.1E-07	2.4E-02	3.4E-05	6.9E-08	NA	NA
Mercury	0.5	7.7E-09	4.5E-05	1.7E-04	6.6E-10	NA	NA
Nickel	23.6	3.6E-07	1.0E-03	3.6E-04	3.1E-08	NA	NA
Selenium	0.9	1.4E-08	4.5E-03	3.1E-06	1.2E-09	NA	NA
Zinc	1105.3	1.7E-05	1.5E-01	1.1E-04	1.5E-06	NA	NA

TOTAL HI =		4.2E-01	TOTAL CANCER RISK =		2.4E-06
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Table 5-30
Inhalation of Airborne Chemicals from On-Site Soil by Trespassers
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{\text{Ca} \cdot \text{IR} \cdot \text{ET} \cdot \text{EF} \cdot \text{ED} \cdot (1/\text{VF} + 1/\text{PEF})}{\text{BW} \cdot \text{AT}}$$

Ca = Concentration in air (mg/m³) = Chemical-specific
 IR - Inhalation rate (m³/hour) = 1.6 [EPA, 1997]
 ET - Exposure time (hours/day) = 2 [professional judgment]
 EF - Exposure frequency (days/year) = 12 [professional judgment]
 VF - Volatilization Factor (m³/kg) = Chemical-specific (see below)
 PEF - Particulate Emission Factor (m³/kg) = 1.32E+09 [EPA, 1991]
 ED - Exposure Duration (years) = 6
 BW - Body weight (kg) = 45
 ATn - Averaging time noncarcinogenic (days) = 2,190
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Soil EPC (mg/kg)	Volatilization Factor (m ³ /kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg-day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	32	3.0E+03	2.5E-05	NA	NA	2.2E-06	NA	NA
Benzene	27	2.1E+04	3.0E-06	1.7E-03	1.7E-03	2.6E-07	2.9E-02	7.4E-09
2-Butanone	1.9	8.2E+03	5.4E-07	2.9E-01	1.9E-06	4.6E-08	NA	NA
Ethylbenzene	110	2.4E+03	1.1E-04	2.9E-01	3.7E-04	9.1E-06	NA	NA
2-Hexanone	0.0053	2.8E+03	4.4E-09	2.3E-02	1.9E-07	3.8E-10	NA	NA
4-Methyl-2-pentanone	140	1.7E+03	2.0E-04	2.0E-02	9.8E-03	1.7E-05	NA	NA
Styrene	3.8	6.1E+03	1.5E-06	2.9E-01	5.0E-06	1.2E-07	NA	NA
1,1,2,2-Tetrachloroethane	0.47	6.0E+03	1.8E-07	NA	NA	1.6E-08	2.0E-01	3.2E-09
Toluene	330	1.8E+03	4.4E-04	1.1E-01	3.9E-03	3.8E-05	NA	NA
Trichloroethane	9.5	1.4E+03	1.6E-05	NA	NA	1.3E-06	6.0E-03	8.0E-09
Xylenes	520	2.5E+03	4.8E-04	NA	NA	4.2E-05	NA	NA
Bis(2-ethylhexyl)phthalate	4000	NA	7.1E-09	NA	NA	6.1E-10	1.4E-02	8.5E-12
Butyl benzyl phthalate	86	NA	1.5E-10	NA	NA	1.3E-11	NA	NA
2-Chlorophenol	0.13	NA	2.3E-13	NA	NA	2.0E-14	NA	NA
1,2-Dichlorobenzene	230	NA	4.1E-10	9.0E-03	4.5E-08	3.5E-11	NA	NA
1,4-Dichlorobenzene	91	NA	1.6E-10	2.3E-01	7.0E-10	1.4E-11	2.2E-02	3.0E-13
2,4-Dichlorobenzene	1.2	NA	2.1E-12	NA	NA	1.8E-13	NA	NA
Di-n-butyl phthalate	36	NA	6.4E-11	NA	NA	5.5E-12	NA	NA
Isophorone	0.1	NA	1.8E-13	NA	NA	1.5E-14	NA	NA
2-Methylnapthalene	130	NA	2.3E-10	NA	NA	2.0E-11	NA	NA
2-Methylphenol	1.9	NA	3.4E-12	NA	NA	2.9E-13	NA	NA
4-Methylphenol	2	NA	3.5E-12	NA	NA	3.0E-13	NA	NA
Naphthalene	86	NA	1.5E-10	9.0E-04	1.7E-07	1.3E-11	NA	NA
Phenanthrene	0.52	NA	9.2E-13	NA	NA	7.9E-14	NA	NA
Phenol	430	NA	7.6E-10	NA	NA	6.5E-11	NA	NA
Pyrene	0.12	NA	2.1E-13	NA	NA	1.8E-14	NA	NA
1,2,4-Trichlorobenzene	350	NA	6.2E-10	5.7E-02	1.1E-08	5.3E-11	NA	NA
Aroclor 1254	38	NA	6.7E-11	NA	NA	5.8E-12	2.0E+00	1.2E-11
Endrin ketone	0.63	NA	1.1E-12	NA	NA	9.6E-14	NA	NA
Antimony	1.7	NA	3.0E-12	NA	NA	2.6E-13	NA	NA
Cadmium	43.7	NA	7.7E-11	NA	NA	6.6E-12	6.3E+00	4.2E-11
Chromium (as Cr+3)	31.5	NA	5.6E-11	5.7E-07	9.8E-05	4.8E-12	NA	NA
Chromium (as Cr+6)	5.24	NA	9.3E-12	3.0E-05	3.1E-07	8.0E-13	4.1E+01	3.3E-11
Copper	52.5	NA	9.3E-11	NA	NA	8.0E-12	NA	NA
Mercury	0.5	NA	8.9E-13	8.6E-05	1.0E-08	7.6E-14	NA	NA
Nickel	23.6	NA	4.2E-11	NA	NA	3.6E-12	NA	NA
Selenium	0.9	NA	1.6E-12	NA	NA	1.4E-13	NA	NA
Zinc	1105.3	NA	2.0E-09	NA	NA	1.7E-10	NA	NA

TOTAL HI = 1.6E-02

TOTAL CANCER RISK = 1.9E-08

Table 5-31
Dermal Exposure to Surface Water by Construction Workers
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_w \cdot SA \cdot PC \cdot ET \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

C_w = Concentration in water (mg/l) = Chemical-specific
 SA - Skin surface area available for exposure (cm²) = 5,300 [EPA, 1997]
 PC - Dermal permeability constant (cm/hr) = Chemical-specific (see Table 5-6)
 ET - Exposure time (hours/day) = 1
 EF - Exposure frequency (days/year) = 60
 ED - Exposure Duration (years) = 1
 CF - Conversion Factor (1 L/1000 cm³) = 1.00E-03
 BW - Body weight (kg) = 70 [EPA, 1991]
 AT_n - Averaging time noncarcinogenic (days) = 365
 AT_c - Averaging time carcinogenic (days) = 25,550

Constituent	Concentration in water (mg/l)	Average Daily Intake (mg/kg-day)	Reference Dose (Dermal) (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg/day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Bis(2-ethylhexyl)phthalate	0.008	3.3E-06	1.1E-02	3.0E-04	4.7E-08	2.6E-02	1.2E-09
TOTAL HI =				3.0E-04	TOTAL CANCER RISK =		1.2E-09

Table 5-32

Ingestion of Surface Water by Trespassers

Greiner's Lagoon Site

Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{\text{Cs} * \text{CR} * \text{ET} * \text{EF} * \text{ED}}{\text{BW} * \text{AT}}$$

Cs = Concentration in water (mg/l) = Chemical-specific
 CR - Contact rate (liters/day) = 0.05 [EPA, 1989]
 ET - Exposure time (hrs/day) = 1
 EF - Exposure frequency (events/yr) = 12
 ED - Exposure Duration (years) = 6
 BW - Body weight (kg) = 45
 ATn - Averaging time noncarcinogenic (days) = 2,190
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Concentration in water (mg/l)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)-1	Cancer Slope Factor (mg/kg-day)-1	Cancer Risk
Bis(2-ethylhexyl)phthalate	0.008	2.9E-07	2.0E-02	1.5E-05	2.5E-08	1.4E-02	3.5E-10
TOTAL HI =				1.5E-05	TOTAL CANCER RISK =		3.5E-10

Table 5-33
Dermal Exposure to Surface Water by Trespassers
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_w \cdot SA \cdot PC \cdot ET \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

C _w - Concentration in water (mg/l) =	Chemical-specific
SA - Skin surface area available for exposure (cm ²) =	3,300 [EPA, 1997]
PC - Dermal permeability constant (cm/hr) =	Chemical-specific (see Table 5-6)
ET - Exposure time (hours/day) =	1
EF - Exposure frequency (days/year) =	12
ED - Exposure Duration (years) =	6
CF - Conversion Factor (1 L/1000 cm ³) =	1.00E-03
BW - Body weight (kg) =	45
AT _n - Averaging time noncarcinogenic (days) =	2,190
AT _c - Averaging time carcinogenic (days) =	25,550

Constituent	Concentration in water (mg/l)	Average Daily Intake (mg/kg-day)	Reference Dose (Dermal) (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg/day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Bis(2-ethylhexyl)phthalate	0.008	6.4E-07	1.1E-02	5.8E-05	5.5E-08	2.6E-02	1.4E-09
TOTAL HI =				5.8E-05	TOTAL CANCER RISK =		1.4E-09

Table 5-34
Dermal Exposure to Sediment by Construction Workers
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_s \cdot SA \cdot AF \cdot ABS \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

Cs = Concentration in sediment (mg/kg) =	Chemical-specific
SA - Skin surface area available for contact (cm ² /day) =	5,300 [EPA, 1997]
AF - Sediment adherence factor (unitless) =	0.6
ABS - Absorption factor (unitless) =	(10% for organics, 1% for inorganics)
EF - Exposure frequency (days/year) =	60
ED - Exposure Duration (years) =	1
CF - Conversion Factor (kg/mg) =	1.00E-06
BW - Body weight for adolescent (kg) =	70 [EPA, 1991]
ATn - Averaging time noncarcinogenic (days) =	365
ATc - Averaging time carcinogenic (days) =	25,550

Constituent	Sediment EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	0.074	5.5E-08	8.3E-02	6.7E-07	7.9E-10	NA	NA
2-Butanone	0.017	1.3E-08	6.0E-01	2.1E-08	1.8E-10	NA	NA
Bis(2-ethylhexyl)phthalate	0.06	4.5E-08	1.1E-02	4.1E-06	6.4E-10	2.6E-02	1.6E-11
Arsenic	6.4	4.8E-07	2.9E-04	1.7E-03	6.8E-09	1.6E+00	1.1E-08
Chromium (as Cr+3)	8.4	6.3E-07	6.0E-02	1.0E-05	9.0E-09	NA	NA
Chromium (as Cr+6)	1.4	1.0E-07	1.2E-04	8.7E-04	1.5E-09	NA	NA
Copper	15.6	1.2E-06	2.4E-02	4.9E-05	1.7E-08	NA	NA
Nickel	16.7	1.2E-06	1.0E-03	1.2E-03	1.8E-08	NA	NA
Zinc	77.2	5.8E-06	1.5E-01	3.8E-05	8.2E-08	NA	NA

TOTAL HI = 3.9E-03 TOTAL CANCER RISK = 1.1E-08

Table S-35
Ingestion of Sediment by Trespassers
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{C_s \cdot IR \cdot FI \cdot EF \cdot ED \cdot CF}{BW \cdot AT}$$

C_s = Concentration in soil (mg/kg) = Chemical-specific
 IR - Ingestion rate (mg soil/day) = 25
 FI - Fraction ingested from source (unitless) = 1
 EF - Exposure frequency (days/year) = 12
 ED - Exposure Duration (years) = 6
 CF - Conversion Factor (kg/mg) = 1.00E-06
 BW - Body weight (kg) = 45
 ATn - Averaging time noncarcinogenic (days) = 2,190
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Sediment EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	0.074	1.4E-09	1.0E-01	1.4E-08	1.2E-10	NA	NA
2-Butanone	0.017	3.1E-10	6.0E-01	5.2E-10	2.7E-11	NA	NA
Bis(2-ethylhexyl)phthalate	0.06	1.1E-09	2.0E-02	5.5E-08	9.4E-11	1.4E-02	1.3E-12
Arsenic	6.4	1.2E-07	3.0E-04	3.9E-04	1.0E-08	1.5E+00	1.5E-08
Chromium (as Cr+3)	8.4	1.5E-07	1.5E+00	1.0E-07	1.3E-08	NA	NA
Chromium (as Cr+6)	1.4	2.6E-08	3.0E-03	8.5E-06	2.2E-09	NA	NA
Copper	15.6	2.8E-07	4.0E-02	7.1E-06	2.4E-08	NA	NA
Nickel	16.7	3.1E-07	2.0E-02	1.5E-05	2.6E-08	NA	NA
Zinc	77.2	1.4E-06	3.0E-01	4.7E-06	1.2E-07	NA	NA
TOTAL HI =				4.3E-04	TOTAL CANCER RISK =		1.5E-08

Table 5-36
Dermal Exposure to Sediment by Trespassers
Greiner's Lagoon Site
Fremont, Ohio

$$\text{Intake (mg/kg-day)} = \frac{\text{Cs} \cdot \text{SA} \cdot \text{AF} \cdot \text{ABS} \cdot \text{EF} \cdot \text{ED} \cdot \text{CF}}{\text{BW} \cdot \text{AT}}$$

Cs = Concentration in sediment (mg/kg) = Chemical-specific
 SA - Adolescent skin surface area (cm²/day) = 3,300 [EPA, 1997]
 AF - Sediment adherence factor (unitless) = 1
 ABS - Absorption factor (unitless) = (10% for organics, 1% for inorganics)
 EF - Exposure frequency (days/year) = 12
 ED - Exposure Duration (years) = 6
 CF - Conversion Factor (kg/mg) = 1.00E-06
 BW - Body weight for adolescent (kg) = 45
 ATn - Averaging time noncarcinogenic (days) = 2,190
 ATc - Averaging time carcinogenic (days) = 25,550

Constituent	Sediment EPC (mg/kg)	Average Daily Intake (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Index	Average Lifetime Daily Intake (mg/kg-day)	Cancer Slope Factor (mg/kg-day) ⁻¹	Cancer Risk
Acetone	0.074	1.8E-08	8.3E-02	2.1E-07	1.5E-09	NA	NA
2-Butanone	0.017	4.1E-09	6.0E-01	6.8E-09	3.5E-10	NA	NA
Bis(2-ethylhexyl)phthalate	0.06	1.4E-08	1.1E-02	1.3E-06	1.2E-09	2.6E-02	3.2E-11
Arsenic	6.4	1.5E-07	2.9E-04	5.4E-04	1.3E-08	1.6E+00	2.1E-08
Chromium (as Cr+3)	8.4	2.0E-07	6.0E-02	3.4E-06	1.7E-08	NA	NA
Chromium (as Cr+6)	1.4	3.4E-08	1.2E-04	2.8E-04	2.9E-09	NA	NA
Copper	15.6	3.8E-07	2.4E-02	1.6E-05	3.2E-08	NA	NA
Nickel	16.7	4.0E-07	1.0E-03	4.0E-04	3.5E-08	NA	NA
Zinc	77.2	1.9E-06	1.5E-01	1.2E-05	1.6E-07	NA	NA

TOTAL HI = 1.3E-03 TOTAL CANCER RISK = 2.1E-08

Table 5-37
Summary of Total Noncarcinogenic Hazards and Carcinogenic Risks
Greiner's Lagoon Site
Fremont, Ohio

	Carcinogenic Risks				Noncarcinogenic Hazard			
	Future Construction Worker	Off-Site Adult Resident	Off-Site Child Resident	Adolescent Trespasser	Future Construction Worker	Off-Site Adult Resident	Off-Site Child Resident	Adolescent Trespasser
Bedrock Ground Water								
ingestion/dermal contact/inhalation	na	1E-06	6E-07	na	na	0.4	0.9	na
Off-Site Perched Ground Water								
dermal contact/inhalation	3E-09	na	na	na	0.01	na	na	na
On-Site Perched Ground Water								
dermal contact/inhalation	1E-06	na	na	na	1.8	na	na	na
Off-Site Soil								
ingestion/dermal contact/inhalation	1E-09	1E-07	1E-07	na	0.06	0.2	0.8	na
On-Site Soil								
ingestion/dermal contact/inhalation	4E-06	na	na	3E-06	5	na	na	0.6
Surface Water								
ingestion/dermal contact	1E-09	na	na	1E-09	0.0003	na	na	0.00007
Sediment								
ingestion/dermal contact	1E-08	na	na	4E-08	0.004	na	na	0.002

na - Exposure pathway considered incomplete and not evaluated within risk assessment (see Table 5-1).
 USEPA has set the acceptable cancer risk range of 1×10^{-4} to 1×10^{-6} and a hazard index for noncarcinogens of 1.0.

Table 6-1

List of Observed Vegetation Within Major Habitat Covertypes

Greiner's Lagoon Site

Fremont, Ohio

Wooded Areas A & B-Mixed Deciduous WoodsTree Canopy

Burr Oak	<i>Quercus macrocarpa</i>
Chestnut Oak	<i>Quercus montana</i>
White Oak	<i>Quercus alba</i>
Red Oak	<i>Quercus rubra</i>
Swamp White Oak	<i>Quercus bicolor</i>
Black Cherry	<i>Prunus serotina</i>
Shagbark Hickory	<i>Carya ovata</i>
Butternut	<i>Juglans cinerea</i>
Black Walnut	<i>Juglans cinerea</i>
Eastern Cottonwood	<i>Populus deltoides</i>
American Sycamore	<i>Platanus occidentalis</i>
American Beech	<i>Fagus grandifolia</i>
Hackberry	<i>Celtis occidentalis</i>
Red Maple	<i>Acer rubrum</i>

Shrub Understory

Dogwood	<i>Cornus sp.</i>
Ironwood	<i>Carpinus caroliniana</i>
Multiflora Rose	<i>Rosa multiflora</i>
Blackberry	<i>Rubus sp.</i>

Sapling / Shrubs

Goldenrods	<i>Salidago sp.</i>
Teasel	<i>Dipsacus sylvestris</i>
Aster	<i>Aster sp.</i>
Evening Primrose	<i>Oenothera biennis</i>
Garlic Mustard	<i>Alliaria officinalis</i>
Common Burdock	<i>Arctium minus</i>
Stiff-haired Sunflower	<i>Helianthus hirsutus</i>
Stinging Nettle	<i>Urtica dioica</i>
Cocklebur	<i>Xanthium chinense</i>
Foxtail Grass	<i>Setaria sp.</i>
Black Locust	<i>Robinia pseudoacacia</i>
Dogwood	<i>Cornus sp.</i>
Black Willow	<i>Salix nigra</i>

Marsh Area

Sedges	<i>Carex sp.</i>
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Ditch

Reed	<i>Phragmites communis</i>
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Stressed Vegetation and Bare Area

Goldenrod	<i>Salidago.sp.</i>
Aster	<i>Aster sp.</i>
Grasses	<i>Poa sp.</i>

Table 6-2
List of Observed and Potential Receptors
Greiner's Lagoon Site
Fremont, Ohio

Common Name	Scientific Name
Mammals	
White-tailed deer*	<i>Odocoileus virginianus</i>
Eastern Cottontail*	<i>Sylvilagus floridanus</i>
Raccoon*	<i>Procyon lotor</i>
Big Brown Bat	<i>Eptesicus fuscus</i>
Eastern Chipmunk	<i>Tamias striatus</i>
Woodchuck	<i>Marmota monax</i>
Eastern Gray Squirrel	<i>Sciurus carolinensis</i>
Eastern Fox Squirrel	<i>Sciurus niger</i>
White-footed Mouse	<i>Peromyscus leucopus</i>
Deer Mouse	<i>Peromyscus maniculatus</i>
Woodland Vole	<i>Microtus pinetorum</i>
Norway Rat	<i>Rattus norvegicus</i>
House Mouse	<i>Mus musculus</i>
Red Fox	<i>Vulpes vulpes</i>
Long-tailed Weasel	<i>Mustela frenata</i>
Striped Skunk	<i>Mephitis mephitis</i>
Virginia Opossum	<i>Dedelphis virginiana</i>
Northern Short-tailed Shrew	<i>Blarina brevicauda</i>
Eastern Mole	<i>Scalopus aquaticus</i>
Eastern Red Bat	<i>Lasiurus borealis</i>
Reptiles and Amphibians	
Marbled Salamander	<i>Ambystoma opacum</i>
Small-mouthed Salamander	<i>Ambystoma texanum</i>
American Toad	<i>Bufo americanus</i>
Woodhouse's Toad	<i>Bufo woodhousei</i>
Chorus Frog	<i>Pseudacris triseriata</i>
Five-lined Skink	<i>Eumeces fasciatus</i>
Rat Snake	<i>Elaphe obsoleta</i>
Eastern Hognose Snake	<i>Heterodon platyhinus</i>
Milk Snake	<i>Lampropeltis triangulum</i>
Common Garter Snake	<i>Thamnophis sirtalis</i>
Birds	
Turkey Vulture	<i>Cathartes aura</i>
Red-tailed Hawk	<i>Buteo jamaicensis</i>
Red-shouldered hawk	<i>Buteo lineatus</i>

Table 6-2
List of Observed and Potential Receptors
Greiner's Lagoon Site
Fremont, Ohio

Common Name	Scientific Name
American Kestrel	<i>Falco sparverius</i>
Ring-necked Pheasant	<i>Phasianus colchicus</i>
Killdeer*	<i>Charadrius vociferus</i>
Mourning Dove*	<i>Zenaidura macroura</i>
Screech Owl	<i>Otus asio</i>
Barn Owl	<i>Tyto alba</i>
Common Nighthawk	<i>Chordeiles minor</i>
Northern Bobwhite	<i>Colinus virginianus</i>
Chimney Swift	<i>Chaetura pelagica</i>
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>
Downy Woodpecker	<i>Picoides pubescens</i>
Hairy Woodpecker	<i>Picoides villosus</i>
Northern Flicker	<i>Colaptes auratus</i>
Eastern Phoebe	<i>Sayornis phoebe</i>
Eastern Kingbird	<i>Tyrannus tyrannus</i>
Loggerhead Shrike	<i>Lanius ludovicianus</i>
Blue Jay*	<i>Cyanocitta cristata</i>
American Crow*	<i>Corvus brachyrhynchos</i>
Barn Swallow	<i>Hirundo rustica</i>
Black-capped Chickadee	<i>Parus atricapillus</i>
Tufted Titmouse	<i>Parus bicolor</i>
Carolina Wren	<i>Thryothorus ludovicianus</i>
House Wren	<i>Troglodytes aedon</i>
Eastern Bluebird	<i>Sialia sialis</i>
American Robin*	<i>Turdus migratorius</i>
Gray Catbird	<i>Dumetella carolinensis</i>
Northern Mockingbird	<i>Mimus polyglottos</i>
Cedar Waxwing	<i>Bombycilla cedrorum</i>
European Starling	<i>Sturnus vulgaris</i>
Yellow Warbler	<i>Dendroica petechia</i>
Northern Cardinal*	<i>Cardinalis cardinalis</i>
Dickcissel*	<i>Spiza americana</i>
Chipping Sparrow	<i>Spizella passerina</i>
Field Sparrow	<i>Spizella pusilla</i>
Vesper Sparrow	<i>Pooecetes gramineus</i>
Lark Sparrow	<i>Chondestes grammacus</i>

Table 6-2
List of Observed and Potential Receptors
Greiner's Lagoon Site
Fremont, Ohio

Common Name	Scientific Name
Grasshopper Sparrow	<i>Ammodramus savannarum</i>
Song Sparrow	<i>Melospiza melodia</i>
Dark-eyed Junco	<i>Junco hyemalis</i>
Lapland Longspur	<i>Calcarius lapponicus</i>
Red-winged Blackbird*	<i>Agelaius phoeniceus</i>
Eastern Meadowlark	<i>Sturnella magna</i>
Common Grackle	<i>Quiscalus quiscula</i>
Brown-headed Cowbird	<i>Molothrus ater</i>
American Goldfinch*	<i>Carduelis tristis</i>
House Sparrow	<i>Passer domesticus</i>
*Observed signs or animal during March 1997 Reconnaissance.	

Table 6-3

On-Site Soil 0-1, 3-5 and 4-6 Feet

Greiner's Lagoon Site, Fremont Ohio

Sample Location	GL-SS-SM-2		GL-SS-SM-7		GL-SS-SM-8		GL-SS-SM-8		GL-SS-SM-9		GL-SS-SM-10		GL-SS-SS		GL-SS-SB-6		GL-SS-SB-8		GL-SS-SB-9		GL-SS-SB-11	
Sample Depth	3'-5'		3'-5'		0'-1'		3'-5'		4'-6'		4'-6'		0'-1'		4-6		4-6		4-6		0-2	
Volatile Organics (ug/kg)																						
Acetone	1100	B	4500	B	61000	U	21000	B	25	U	25	U	1300	B	23	U	48	J	18	J	46000	U
2-Butanone	3000	U	6100	U	61000	U	59000	U	25	U	25	U	5200	U	23	U	24	U	24	U	46000	U
Trichloroethene	750	U	1400	J	9500	J	7700	J	6.1	U	6.2	U	1300	U	5.8	U	6	U	6.1	U	12000	U
Benzene	350	J	4300		27000		25000		6.1	U	6.2	U	1300	U	5.8	U	6	U	6.3		12000	U
4 Methyl-2-pentanone	6800	J	50000	J	100000	J	140000		25	U	25	U	5200	U	23	U	7.7	B	24	U	40000	B
2-Hexanone	3000	U	6100	U	61000	U	59000	U	25	U	25	U	5200	U								
1,1,2,2-Tetrachloroethane	750	U	1500	U	15000	U	15000	U	6.1	U	6.2	U	1300	U								
Toluene	11000		43000		330000		290000		6.1	U	6.2	U	1300		5.8	U	6	U	6.1	U	85000	
Ethylbenzene	8100		10000		97000		110000		6.1	U	6.2	U	3500		5.8	U	6	U	6.1	U	48000	
Styrene	3800		1500	U	15000	U	15000	U	6.1	U	6.2	U	1300	U	5.8	U	6	U	6.1	U	12000	U
Xylenes (total)	38000		51000		460000		520000		6.1	U	3.6	J	26000		5.8	U	6	U	6.1	U	250000	
Semivolatile Organics (ug/kg)																						
Phenol	21000	J	130000	J	430000	J	330000	J	400	U	410	U	170000	U	380	U	400	UJ	400	U	170000	U
2-Chlorophenol	79000	U	160000	U	560000	U	390000	U	400	U	410	U	170000	U								
1,4-Dichlorobenzene	79000	U	160000	U	91000	J	390000	U	400	U	410	U	170000	U	380	U	400	UJ	400	U	170000	U
1,2-Dichlorobenzene	79000	U	31000	J	230000	J	390000	U	400	U	410	U	170000	U	380	U	400	UJ	400	U	39000	J
2-Methylphenol	79000	U	160000	U	560000	U	390000	U	400	U	410	U	170000	U	380	U	400	UJ	400	U	170000	U
4-Methylphenol	79000	U	160000	U	560000	U	390000	U	400	U	410	U	170000	U	380	U	400	UJ	400	U	170000	U
Isophorone	79000	U	160000	U	560000	U	390000	U	400	U	410	U	170000	U	100	J	400	UJ	400	U	170000	U
2,4-Dimethylphenol	79000	U	160000	U	560000	U	390000	U	400	U	410	U	170000	U	380	U	400	UJ	400	U	170000	U
1,2,4-Trichlorobenzene	79000	U	42000	J	350000	J	390000	U	400	U	410	U	170000	U	380	U	400	UJ	400	U	58000	J
Naphthalene	8600	J	160000	U	86000	J	390000	U	400	U	410	U	170000	U	380	U	400	UJ	400	U	26000	J
2-Methylnaphthalene	79000	U	18000	J	130000	J	390000	U	400	U	410	U	170000	U	380	U	400	UJ	400	U	26000	J
Phenanthrene	79000	U	160000	U	560000	U	390000	U	400	U	410	U	170000	U	380	U	400	UJ	400	U	170000	U
Di-n-butyl phthalate	79000	U	160000	U	560000	U	390000	U	400	U	410	U	36000	J	380	U	400	UJ	400	U	170000	U
Pyrene	79000	U	160000	U	560000	U	390000	U	400	U	410	U	170000	U								
Butyl benzyl phthalate	79000	U	160000	U	560000	U	390000	U	400	U	410	U	86000	J	380	U	400	UJ	400	U	170000	UJ
bis(2-Ethylhexyl) phthalate	550000		720000		4000000		2700000		1000		1100		870000		380	U	270	J	400	U	510000	J
Pesticide/PCB (ug/kg)																						
Endrin ketone			820	U	4000	U			4	U			4200	U								
Aroclor 1254			8200	U	40000	U			40	U			38000	J	38	U	40	U	40	UJ	2.7	J
Metals (mg/kg)																						
Antimony			1.2	UJ	6.2	J			1.2	UJ			1.3	U								
Arsenic			5.8		7.1				4.5				8.8									
Cadmium			8.5		43.7				0.24	U			7.5									
Chromium			21.9		94.6				6.2				22.7									
Copper			30.5	J	102	J			8.0	J			29.3									
Lead			228	J	811	J			4.8	J			98.0									
Mercury			0.33		1.3				0.12	U			0.33									
Nickel			13.8	J	31.3	J			9.8	J			18.6									
Selenium			0.61	UJ	3.4	J			0.6	UJ			0.63	UJ								
Zinc			407		2470	J			30.3	J			175									

Notes:

J - This result should be considered a quantitative estimate.

B - This result is qualitatively invalid since this analyte was detected in a blank at a similar concentration.

U - This compound was analyzed but not detected. The numerical value represents the quantitation limit of the compound.

UJ - This compound was analyzed but not detected. The numerical value that represents the quantitation limit of the compound is a quantitative estimate.

Table 6-4
Off-Site Soil 0-1, 3-5 and 4-6 Feet
Greiner's Lagoon Site, Fremont Ohio

Sample Location Sample Depth	GL-SS-GB-14 4-6'	GL-SS-GB-15 4-6'	GL-SS-GB-17 2-4'	GL-SS-GB-1 4-6'	GL-SS-GB-6 2-4'	GL-SS-GB-8 2-4'	GL-SS-GB-13 4-6'					
<i>Volatile Organics</i>												
Acetone	23	U	26	U	23	UJ						
2-Butanone	23	U	26	U	23	U						
Benzene	5.7	U	6.4	U	5.8	UJ						
4-Methyl-2-pentanone	23	U	26	U	23	UJ						
<i>Semivolatile Organics</i>												
Phenol	380	U	420	U	390	U						
2-Methylphenol	380	U	420	U	390	U						
4-Methylphenol	380	U	420	U	390	U						
Naphthalene	380	U	420	U	390	U						
bis(2-Ethylhexyl) phthalate	380	U	420	U	390	U						
<i>Metals</i>												
Arsenic		5.0	J		2.6	J	9.0	J	2.3	J	1.5	J
Cadmium		0.24	U		0.23	U	0.29	U	0.24	U	0.24	U
Chromium		8.4			5.2		10.9		12.1		4.0	
Copper		15.4			8.8		11.1		6.2		7.3	
Lead		8.6	J		5.0	J	13.5	J	6.5	J	4.1	J
Nickel		17.3			11.6		17.3		14.1		7.3	
Zinc		50.6			28.2		63.1		54.4		27.1	

Notes:

J - This result should be considered a quantitative estimate.

U - This compound was analyzed but not detected. The numerical value represents the quantitation limit of the compound.

UJ - This compound was analyzed but not detected. The numerical value that represents the quantitation limit of the compound is a quantitative estimate.

Table 6-5

Screening Analysis of Maximum Constituent Concentrations in On-Site Soil
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Number of Samples	Maximum Concentration	Screening Level (ppm)		EEQ
Volatile Organic Compounds (mg/Kg)					
Acetone	11	0.048	-	-	-
Benzene	11	27	0.5	(a)	54
Ethylbenzene	11	110	5	(a)	22
4-Methyl-2-pentanone	11	140	100	(b)	1.4
Styrene	11	3.8	5	(a)	0.8
Toluene	11	330	3	(a)	110
Trichloroethene	11	9.5	5	(a)	1.9
Xylenes (total)	11	520	5	(a)	104
Semivolatile Organic Coumpounds (mg/Kg)					
Butyl benzyl phthalate	11	86	-	-	-
1,2-Dichlorobenzene	11	230	1	(a)	230
1,4-Dichlorobenzene	11	91	1	(a)	91
Di-n-butyl phthalate	11	36	-	-	-
bis(2-Ethylhexyl)phthalate	11	4000	70	(a)	57
Isophorone	11	0.1	-	-	-
2-Methylnaphthalene**	11	130	5	(a)	26
Naphthalene	11	86	5	(a)	17
Phenol	11	430	1	(a)	430
1,2,4-Trichlorobenzene	11	350	1	(a)	350
Metals (mg/Kg)					
Antimony	3	6.2	4.5	(a)	1.4
Arsenic	3	8.8	30	(a)	0.3
Cadmium	3	43.7	5	(a)	8.7
Chromium	3	94.6	250	(a)	0.4
Copper	3	102	100	(a)	1.0
Lead	3	811	150	(a)	5.4
Mercury	3	1.3	2	(a)	0.7
Nickel	3	31.3	100	(a)	0.3
Selenium	3	3.4	3	(a)	1.1
Zinc	3	2470	500	(a)	4.9
Pesticides/PCBs (mg/Kg)					
Aroclor 1254	8	38	0.05	(a)	760

Notes:

(a) Evaluating Soil Contamination by Nelson Beyer. 1990. U.S. Fish & Wildlife Service
Biological Report 90(2), Pgs.2, 3, 5 & 7.

(b) USEPA. 1995. Revised Region III BTAG Screening Levels.

**Screening level for naphthalene.

Table 6-5a

Screening Analysis of Maximum Constituent Concentrations in Off-Site Soil

Greiner's Lagoon Site

Fremont, Ohio

Constituent	Number of Samples	Maximum Concentration	Screening Level (ppm)	EEQ
Metals (mg/Kg)				
Arsenic	5	9	30	(a) 0.3
Chromium	5	12.1	250	(a) 0.05
Copper	5	15.4	100	(a) 0.2
Lead	5	13.5	150	(a) 0.1
Nickel	5	17.3	100	(a) 0.2
Zinc	5	63.1	500	(a) 0.1

Notes:

(a) Evaluating Soil Contamination by Nelson Beyer. 1990. U.S. Fish & Wildlife Service
Biological Report 90(2), Pgs.2, 3, 5 & 7.

Table 6-6

Summary of Constituents of Potential Concern in On-Site Soil with EEQs Greater than One
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Maximum Concentration	Screening Level (ppm)		EEQ
Volatile Organic Compounds (mg/Kg)				
Acetone	0.048	-		-
Benzene	27	0.5	(a)	54
Ethylbenzene	110	5	(a)	22
Toluene	330	3	(a)	110
Trichloroethene	9.5	5	(a)	1.9
Xylenes (total)	520	5	(a)	104
Semivolatile Organic Coumpounds (mg/Kg)				
Butyl benzyl phthalate	86	-		-
1,2-Dichlorobenzene	230	1	(a)	230
1,4-Dichlorobenzene	91	1	(a)	91
Di-n-butyl phthalate	36	-		-
bis(2-Ethylhexyl)phthalate	4000	70	(a)	57
Isophorone	0.1	-		-
2-Methylnaphthalene**	130	5	(a)	26
Naphthalene	86	5	(a)	17
Phenol	430	1	(a)	430
1,2,4-Trichlorobenzene	350	1	(a)	350
Metals (mg/Kg)				
Cadmium	43.7	5	(a)	8.7
Lead	811	150	(a)	5.4
Zinc	2470	500	(a)	4.9
Pesticides/PCBs (mg/Kg)				
Aroclor 1254	38	0.05	(a)	760

Notes:

(a) Evaluating Soil Contamination by Nelson Beyer. 1990. U.S. Fish & Wildlife Service
Biological Report 90(2), Pgs.2, 3, 5 & 7.

(b) USEPA. 1995. Revised Region III BTAG Screening Levels.

**Screening level for naphthalene.

Table 6-7
Summary of Sediment and Surface Water Constituents of Potential Concern
Greiner's Lagoon Site
Fremont, Ohio

Constituent	Maximum in Sediment (mg/kg)	Screening Level (mg/kg)		EEQ	Maximum in Surface Water (mg/l)	Screening Level (mg/l)		EEQ
Volatile Organic Compounds								
Acetone	0.074	0.0087	(a)	8.5	-	-		-
2-Butanone	0.017	0.27	(a)	0.1	-	-		-
Semivolatile Organic Compounds								
bis(2-Ethylhexyl)phthalate	0.06	890	(a)	0.0001	0.008	0.003	(a)	2.7
Metals								
Arsenic	6.4	8.2	(a)	0.78	-	-		-
Chromium	9.8	81	(a)	0.12	-	-		-
Copper	15.6	34	(a)	0.46	-	-		-
Lead	10.3	46.7	(a)	0.22	0.0061	0.0032	(a)	1.9
Nickel	16.7	20.9	(a)	0.80	-	-		-
Zinc	77.2	150	(a)	0.51	-	-		-

Notes:

(a) Oak Ridge National Laboratory, 1996 and 1997.

TABLE 8-1
COMPARATIVE ANALYSIS OF PROPOSED SOIL TREATMENT TECHNOLOGIES
Greiner's Lagoon Site
Fremont, Ohio

COMPARATIVE CRITERIA/OBJECTIVE	ON-SITE INCINERATION	LOW TEMPERATURE THERMAL DESORPTION	SOIL PHYSICAL SOLIDIFICATION	SOIL CHEMICAL STABILIZATION	BIOLOGICAL TREATMENT	PHYTOREME- DIATION
Proven ability to reduce constituent concentrations	+	+	-	-	+(organic)	+
Effective across wide range of soil/sediment types	-	-	+	+	-	+
In most cases, produces no residual wastes that must be treated and/or disposed	-	+	+	+	+	+
Not effected by higher moisture contents	-	-	0	-	-	+
No off-gases produced that must be treated prior to release	-	-	0	0	0	+
No potential for accidental off gas release	-	-	0	0	0	0
Not subject to negative public perception	-	0	+	+	0	+
No long term on-site monitoring required	+	+	0	0	0	-
Long lead time is not needed to set up on-site system	-	0	+	+	-	+
Alternative does not produce waste increase.	+	+	-	-	0	+
Treatment Costs \$ per ton.*	\$100-\$290	\$80-\$120	\$30	\$43	\$50-\$260	\$10-\$35

KEY:

- * These costs do not include substantial activities such as mobilization and demobilization, test burns, and associated analytical testing.
- +
- Indicates that this removal action alternative usually meets this particular comparative criteria/objective.
- 0
- Indicates that the removal action alternative occasionally meets this particular comparative criteria/objective.
-
- Indicates that the removal action alternative rarely meets this particular comparative criteria/objective.

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**TABLE 8-3
COMPARATIVE COSTS OF ALTERNATIVES
Greiner's Lagoon Site, Fremont, Ohio**

TECHNOLOGY /PROCESS	ALTERNATIVE 1 CAPITAL	ALTERNATIVE 1 ANNUAL O&M	ALTERNATIVE 2 CAPITAL	ALTERNATIVE 2 ANNUAL O&M	ALTERNATIVE 3 CAPITAL	ALTERNATIVE 3 ANNUAL O&M	ALTERNATIVE 4 CAPITAL	ALTERNATIVE 4 ANNUAL O&M	ALTERNATIVE 5 CAPITAL	ALTERNATIVE 5 ANNUAL O&M	ALTERNATIVE 6 CAPITAL	ALTERNATIVE 6 ANNUAL O&M
Engineered Clay Cap	\$525,000	\$15,000	\$525,000	\$15,000								
OAC3745-27-11 Cap							\$928,000	\$15,000	\$928,000	\$15,000		
Selective In-Situ Solidification	\$450,000	\$0					\$450,000	\$0				
In-Situ (Chemical) Stabilization			\$4,030,000	\$0					\$4,030,000	\$0		
Phytoremediation-based Cover											\$124,500	\$10,000
Soil Amendment											\$115,000	
Soil Excavation					\$787,000	\$0						
Off-Site RCRA Landfill Disposal					\$4,067,000	\$0						
Transportation					Included	\$0						
Off-Site Solid Waste Landfill Disposal					\$1,176,000	\$0						
Transportation					Included	\$0						
Backfill					\$994,000							
Water Management	\$76,000	\$3,000	\$76,000	\$3,000	\$76,000	\$3,000	\$76,000	\$3,000	\$76,000	\$3,000	\$76,000	\$3,000
Monitored Natural Attenuation	\$0	\$10,000	\$0	\$10,000	\$0	\$0	\$0	\$10,000	\$0	\$10,000		\$10,000
Site Access Restriction	\$64,000	\$0	\$64,000	\$0	\$64,000	\$0	\$64,000	\$0	\$64,000	\$0	\$64,000	\$0
Engineering/ Oversight	\$113,000	\$0	\$180,000	\$0	\$150,000	\$0	\$113,000	\$0	\$180,000	\$0	\$105,000	\$5,000
Legal, Insurance & Permits	\$100,000	\$4,000	\$100,000	\$4,000	\$100,000	\$4,000	\$100,000	\$4,000	\$100,000	\$4,000	\$100,000	\$4,000
Sub Total	\$1,328,000	\$32,000	\$4,975,000	\$32,000	\$7,914,000	\$7,000	\$1,731,000	\$32,000	\$5,378,000	\$32,000	\$584,500	\$32,000
Contingencies (10%)	\$133,000	\$3,200	\$498,000	\$3,200	\$791,000	\$700	\$173,000	\$3,200	\$538,000	\$3,200	\$58,450	\$3,200
Total	\$1,461,000	\$35,200	\$5,473,000	\$35,200	\$8,705,000	\$7,700	\$1,904,000	\$35,200	\$5,916,000	\$35,200	\$642,950	\$35,200
Net Present Worth Cost-Capital	\$1,461,000		\$5,473,000		\$8,705,000		\$1,904,000		\$5,916,000		\$642,950	
Net Present Worth Cost-O & M	\$541,000		\$541,000		\$119,000		\$541,000		\$541,000		\$541,000	
Net Present Worth Cost-Capital and O & M	\$2,002,000		\$6,014,000		\$8,824,000		\$2,445,000		\$6,457,000		\$1,184,000	

Alternative 1: Engineered Clay Cap; Selective Soil Physical Solidification; Access Control; Monitored Natural Attenuation

Alternative 2: Engineered Clay Cap; Soil Chemical Stabilization; Access Control; Monitored Natural Attenuation

Alternative 3: Excavation; Off-Site Landfilling; Backfill with Clean Fill; Access Control

Alternative 4: OAC 3745-27-11 Cap; Selective Soil Physical Solidification; Access Control; Monitored Natural Attenuation

Alternative 5: OAC 3745-27-11 Cap; Soil Chemical Stabilization; Access Control; Monitored Natural Attenuation

Alternative 6: Phytoremediation (Hydraulic Control and Treatment); Access Control; Monitored Natural Attenuation

**Table 9-1
Summary of Comparison of Removal Action Alternatives
Orion's Lagoons Site
Painesville, Ohio**

Criteria	Alternative 1: Engineering Clay Cap, Selective Soil Physical Stabilization, Access Control, Monitored Natural Attenuation	Alternative 2: Engineered Clay Cap, Soil Vapor Extraction, Access Control, Monitored Natural Attenuation	Alternative 3: Excavation, Off-site Landfilling, Access Control	Alternative 4: LIAI (750-2711) Cap, Selective Soil Physical Stabilization, Access Control, Monitored Natural Attenuation	Alternative 5: LIAI (750-2711) Cap, Soil Vapor Extraction, Access Control, Monitored Natural Attenuation	Alternative 6: Phytoremediation (Hydraulic Control and Treatment), Access Control, Monitored Natural Attenuation
Timeliness						
Can be implemented in one year	Yes, under normal weather conditions. Requires maintenance over a 30-year period.	Yes, under normal weather conditions. Requires maintenance over a 30-year period.	Yes, under normal weather conditions.	Yes, under normal weather conditions. Requires maintenance over a 30-year period.	Yes, under normal weather conditions. Requires maintenance over a 30-year period.	Yes, under normal weather conditions. Requires maintenance over a 30-year period.
Results in acceptable short and long term effects on the environment	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective
Protection of Human Health and the Environment						
Provides short and long term minimization of the potential for receptor exposure to off-site media	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective
Prevents during implementation	Some risk, but minimized by using conventional remediation health and safety procedures.	Increased on-site risk, but may be minimized by using conventional remediation health and safety procedures.	Prevented risk during transportation of materials to the disposal facility from dust emissions, noise, vibration, and emissions.	Some risk, but minimized by using conventional remediation health and safety procedures.	Increased on-site risk, but may be minimized by using conventional remediation health and safety procedures.	Some risk, but minimized by using conventional remediation health and safety procedures.
Impact on adjoining property anticipated effects on the community and community reaction	With the use of access and dust/spray controls during construction, the surrounding community is not expected to have significant concerns about this alternative.	With the use of access and dust/spray controls during construction, the surrounding community is not expected to have significant concerns about this alternative.	Community reaction not expected to be favorable due to human health and environmental concerns and perception of unwanted fuel consumption.	With the use of access and dust/spray controls during construction, the surrounding community is not expected to have significant concerns about this alternative.	With the use of access and dust/spray controls during construction, the surrounding community is not expected to have significant concerns about this alternative.	With the use of access and dust/spray controls during construction, the surrounding community is not expected to have significant concerns about this alternative.
Is residual effect concerns	Monitored natural attenuation for ground water.	Monitored natural attenuation for ground water.	No monitored natural attenuation for ground water.	Monitored natural attenuation for ground water.	Monitored natural attenuation for ground water.	Monitored natural attenuation for ground water.
Technical Feasibility						
Ability to implement the alternative based on current developmental status of the technology	Yes	Yes	Yes	Yes	Yes	Yes
Equipment, personnel, and services available to implement this alternative	Yes	Yes	Yes	Yes	Yes	Yes
Off-site treatment and disposal capacity available (unmonitored)	N/A	N/A	Yes	N/A	N/A	N/A
Performance/total life	Yes	Yes	Yes	Yes	Yes	Reimagined alternative new technology
Extent to which alternative can achieve the removal action objective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective	Highly Effective
Major Institutional Considerations						
Practical compliance with ARARs	May require an ARAR waiver since the engineered cap may not meet the substantive requirements.	May require an ARAR waiver since the engineered cap may not meet the substantive requirements.	Compliance readily attained.	Compliance readily attained.	Compliance readily attained.	Compliance readily attained.
Potential regulatory requirements in regards to permitting and timeliness of review	Regulatory review periods may not be realistic for documents necessary to implement this alternative, possible variance of ARAR provisions.	Regulatory review periods may not be realistic for documents necessary to implement this alternative, possible variance of ARAR provisions.	Does not require any unusual approvals or permits.	Does not require any unusual approvals or permits.	Does not require any unusual approvals or permits.	Does not require any unusual approvals or permits.
Cost Analysis						
Net Present Worth Cost Capital	\$1,661,000	\$1,673,000	\$1,705,000	\$1,904,000	\$1,916,000	\$642,950
Net Present Worth Cost-O & M	\$341,000	\$341,000	\$110,000	\$341,000	\$341,000	\$341,000
Net Present Worth Cost-Capital and O & M	\$2,002,000	\$2,014,000	\$1,815,000	\$2,245,000	\$2,257,000	\$983,950